Safety of Noncardiac Surgery in Patients With Hypertrophic Obstructive Cardiomyopathy at a Tertiary Care Center

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Objectives: **This study's purpose was to review noncardiac surgery (NCS) in patients with hypertrophic obstructive cardiomyopathy (HOCM) to examine perioperative management and quantify postoperative mortality and worsening heart failure.**

Design: **Retrospective review.**

Setting: **A single tertiary care center.**

Participants: **The study included 57 adult patients with HOCM who underwent NCS from January 1, 1996, through January 31, 2014.**

Interventions: **Noncardiac surgery.**

Measurements and Main Results: **The authors identified 57 HOCM patients who underwent 96 NCS procedures. Vasoactive medications were administered to the majority of NCS patients. Three patients (3%) died within 30 days of NCS, but causes of death did not appear to be cardiac in nature. Death after NCS was not significantly associated with preoperative left ventricular ejection fraction ($p = 0.2727$) or peak instantaneous systolic resting gradient (0.8828), but was associated with emergency surgery ($p = 0.0002$). Three patients experienced worsening heart failure postoperatively, and this was significantly associated with preoperative New York Heart Association Class III-IV symptoms compared with I-II symptoms ($p = 0.0008$).**

Conclusions: **HOCM patients safely can undergo NCS at multidisciplinary centers experienced in caring for these patients. The mortality rate in this study was less than that reported in the majority of other studies. Postoperative complications, including increasing heart failure, may occur, especially in patients with more severe preoperative cardiac symptoms.**

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HYPERTROPHIC OBSTRUCTIVE CARDIOMYOPATHY (HOCM) is an autosomal dominant disease consisting of asymmetric left ventricular hypertrophy that leads to systolic anterior motion of the mitral valve, left ventricular obstruction, and mitral regurgitation.[1,2] It may present at any age.[3] Patients with classic HOCM have hypertrophy of the left ventricular basal septum. Other variants of HOCM involve obstruction at the apical or midventricular regions.[1,3,4] Patients may experience heart failure, palpitations, diastolic dysfunction, stroke, arrhythmias, syncope, and sudden cardiac death. Surgical treatment of HOCM is known to improve long-term survival compared with patients who do not undergo surgery.[5] HOCM should be differentiated from non-obstructive hypertrophic cardiomyopathy (HCM), which involves left ventricular hypertrophy without evidence of obstruction, and is associated with a lower mortality compared with HOCM.[5-7]

Patients with HOCM may present for noncardiac surgery (NCS) without having undergone prior surgical repair of their cardiac disease. Prior retrospective series reported mortality or adverse events in HCM patients undergoing NCS, ranging from 0% to 40%.[8-11] However, 3 of these studies included patients with HOCM and non-obstructive HCM,[8,10,11] and the other study from 1985 included a relatively small number of HOCM patients.[9] The purpose of this study was to retrospectively review NCS in patients with HOCM at a single tertiary care institution that serves as a large referral center for HOCM patients. The authors hypothesized that HOCM patients safely can undergo NCS with low risk of mortality or major adverse cardiac events, such as myocardial infarction or heart failure, at experienced centers. Specifics related to anesthetic and hemodynamic management of these patients previously have been reviewed.[12-15]

METHODS

This study was approved by the Mayo Foundation Institutional Review Board. All patients gave consent to use of their records for research purposes. The electronic medical record database was searched[16] from January 1, 1996, through January 31, 2014, to identify patients with HOCM listed as a diagnosis or in their past medical histories. Pediatric patients (age <18 years), individuals not consenting to use of their record for research purposes, and those who had undergone surgical treatment for HOCM (ie, alcohol ablation or surgical myectomy) before NCS were not included. Patients were then cross-referenced with a surgical database to include only those HOCM patients who had undergone NCS requiring general anesthesia or neuraxial anesthesia at the Mayo Clinic, Rochester, MN. Resulting individual patient records were reviewed by a single author (TLB) to verify presence of HOCM and NCS.

Similar to guidelines defining severity of regurgitant and stenotic cardiac valvular lesions,[17] guidelines exist that differentiate HCM from HOCM.[18] These guidelines, general consensus, and published studies consider a peak instantaneous left ventricular systolic gradient $\geq$30 mmHg by continuous-wave Doppler echocardiography indicative of obstruction and adverse outcomes in population-based studies.[5-7,18,19] The authors delineated HOCM from non-obstructive HCM by using a lower limit peak instantaneous left ventricular systolic outflow gradient (either resting or provoked) of $\geq$30 mmHg as

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determined by echocardiography before NCS. The authors chose to include patients with latent obstruction (<30 mmHg) at rest who demonstrated obstruction (≥30 mmHg) with provocation (Valsalva maneuver or inhaled amyl nitrite administration), given the labile nature of the obstruction that may be provoked under the hemodynamically altering effects of anesthesia. However, patients with apical-variant HOCM and those without resting or provokable left ventricular systolic peak instantaneous gradients of ≥30 mmHg were excluded.

Preoperative and demographic information collected included patient age at NCS, sex, hemoglobin values, creatinine values, cardiac rhythm on electrocardiogram, New York Heart Association (NYHA) heart failure classification, history of cardiac arrest, history of syncope, history of congestive heart failure, history of stroke or transient ischemic attack, presence of diabetes mellitus requiring insulin, and chronic kidney disease with creatinine >2 mg/dL. Preoperative echocardiographic data recorded included left ventricular ejection fraction, resting left ventricular outflow tract (LVOT) gradient, provoked (Valsalva maneuver or inhaled amyl nitrite administration) LVOT gradient, left ventricular basal septum thickness, and mitral regurgitation severity.

The intraoperative anesthetic records and surgical notes were reviewed for type of surgery, emergency versus nonemergency surgery, anesthesia type (general *v* neuraxial), duration of anesthesia (as determined from the documented anesthesia start and stop times), whether care was provided by a cardiac anesthesiologist (defined as an anesthesiologist who completed a cardiac anesthesiology fellowship), presence of invasive monitors (arterial, central venous, and pulmonary artery lines), use of transesophageal echocardiography, intraoperative cardiac arrest, the use of vasoactive medications (phenylephrine, ephedrine, vasopressin, esmolol, and metoprolol), and estimated blood loss (as documented in the anesthetic record).

Postoperative records for the 30 days after NCS were searched for death (and cause of death when present), hospital readmission (and reason for readmission), cardiac arrest, stroke (as defined as having received a new diagnosis of stroke in the postoperative period), myocardial infarction, and increasing heart failure (defined as notation in the postoperative documentation of worsening heart failure). Hospital length of stay also was noted.

Statistical analysis consisted of mean, standard deviation, median, and range determination for continuous variables and percent quantification for categorical variables. As exploratory analyses, the authors performed tests for associations between preoperative echocardiographic characteristics of HOCM (ejection fraction and resting left ventricular systolic peak instantaneous gradient) and death as well as emergency surgery and death. In addition, the authors performed a test for association between preoperative NYHA heart failure classifications (I-II compared with III-IV) and occurrence of postoperative heart failure. In this population with a small number of events and clustering within patients, associations between the categorical variables emergency surgery and death ideally would be tested with an exact test that also accounts for clustering. The largest cluster sizes exceeded two admissions, so no methods have been developed for this purpose.[20] Thus, the authors calculated

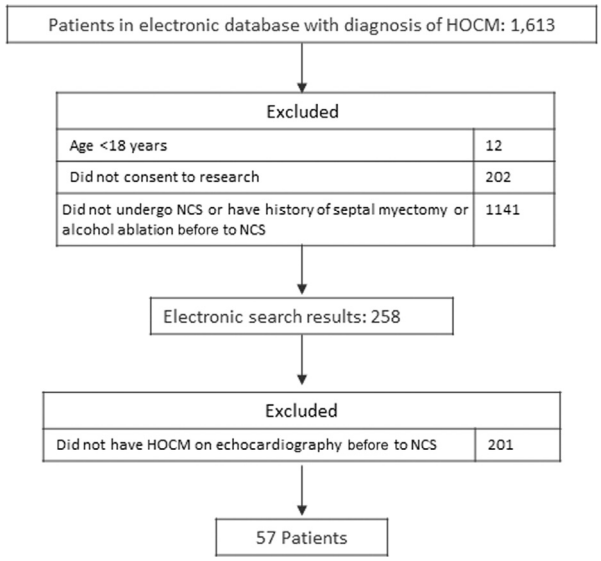

Fig 1. Selection process for patients with hypertrophic obstructive cardiomyopathy undergoing noncardiac surgery. HOCM, hypertrophic obstructive cardiomyopathy; NCS, noncardiac surgery.

statistical significance with the Rao-Scott test and present p values for these tests. Given the limitations of this test, the authors also calculated statistical significance using the Fisher's test (which is an exact test) and by using robust standard errors (PROC GENMOD; SAS Institute, Cary, NC).[21] In all instances, p values were very similar. Analyses were performed using SAS, version 9.3 (SAS Institute).

RESULTS

Search of the electronic medical database after exclusion of patients with non-obstructive HCM resulted in 57 HOCM patients undergoing 96 NCS (Fig 1). Mean age was 62 ± 16 years, and 52 of the 96 NCS (54%) were performed on men. Other demographic and preoperative information, including echocardiographic findings, are shown in Table 1. The majority (89.6%) of patients were NYHA classification I or II before NCS.

Patients underwent a variety of types of NCS (Table 2). Eight surgeries (8%) were emergency procedures. All surgeries were performed with the patient under general anesthesia, except for 1 patient (1%) who underwent uneventful revision hip arthroplasty under spinal anesthesia with concomitant sedation. Intraoperative findings for the 96 NCS are listed in Table 2. A cardiac anesthesiologist cared for the patient in 16 NCS (17%). Arterial and central venous lines were present in 24 (25%) and 9 (9%) of NCS, respectively. A pulmonary artery catheter and transesophageal echocardiography were each used for 1 NCS (in separate surgeries). Red blood cell transfusions were administered in 15 NCS (16%). No patient experienced cardiac arrest intraoperatively.

Within 30 days of NCS, 3 deaths occurred (3%). Two deaths occurred secondary to perioperative aspiration events, and 1 was secondary to bowel ischemia not amenable to surgical intervention. Additional details related to these deaths are listed in Table 3. Statistical analysis revealed only

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