Appropriateness of Coronary Artery Bypass Graft Surgery Performed in Northern New England

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Objectives
The goal of this study was to assess the concordance between the American College of Cardiology (ACC) and the American Heart Association (AHA) 2004 Guideline Update for Coronary Artery Bypass Graft Surgery and actual clinical practice.

Background
There is substantial geographic variability in the population-based rates of coronary artery bypass graft (CABG) procedures, and in recent years, there have been several public concerns about unnecessary cardiac care. The actual rate of inappropriate cardiac procedures is unknown.

Methods
We evaluated 4,684 consecutive isolated coronary artery bypass graft procedures performed in 2004 and 2005 in northern New England. Our regional registry data were used to categorize patients into clinical subgroups. Detailed clinical criteria were then used to categorize procedures within these subgroups as class I (useful and effective), class IIa (evidence favors usefulness), class IIb (evidence less well established), and class III (not useful or effective).

Results
Among these 4,684 procedures, we were able to classify 99.6% (n = 4,665). The majority of procedures were class I (87.7%). Class II procedures totaled 10.9%. The remaining 1.4% of procedures were class III.

Conclusions
In this regional study, we found that 98.6% of CABG procedures that could be classified were considered to be appropriate. In these data, actual clinical practice closely follows the recommendations of the 2004 ACC/AHA guidelines for CABG surgery. (J Am Coll Cardiol 2008;51:2323–8) © 2008 by the American College of Cardiology Foundation

Since it was first described by Favaloro (1) and Garrett et al. (2), coronary artery bypass graft (CABG) surgery has become one of the most commonly performed and closely examined major surgical procedure. In 2003, it was estimated that there were 348,218 CABG procedures performed in the U.S. (3). Among Medicare enrollees, there is more than 5-fold variability in the population-based rates of CABG procedures and this has raised concerns about the inappropriate use of this procedure (4). In recent years, there have been several public accusations of unnecessary cardiac care (5–7). These have originated from a variety of sources including patient complaints, insurance company concerns, and medical staff actions. The actual rate of inappropriate cardiac surgery is unknown, but it can be assessed by a detailed comparison of actual clinical practice to the professional guidelines.

Evidence-based guidelines for CABG surgery have been available for many years. In 1972, Wright and Frederickson (8) edited a report on the minimum resources required to perform cardiac surgery safely. In 1980, the American
Clinical subgroups as described in the guidelines are not mutually exclusive. It was possible for patients to fall into more than 1 subgroup. For example, prior CABG procedure or failed PTCA may coexist with any of the other clinical subgroups. In order to calculate the appropriateness classes, it was necessary to assign patients to a single clinical subgroup. In this analysis, 71.0% of patients were coded into 1 group, 23.6% into 2 groups, 4.7% into 3 groups, and 0.7% into 4 groups. If a patient was included in more than 1 subgroup, we assigned that patient to the clinical subgroup with the highest mortality risk. The observed in-hospital mortality rates following CABG procedure were as follows: stable angina (1.0%), asymptomatic or mild angina (1.7%), unstable angina/non–ST-segment elevation myocardial infarction (2.4%), poor left ventricular function (3.8%), with previous CABG (4.2%), ST-segment elevation myocardial infarction (6.7%), and failed PTCA (10.7%). Within each clinical subgroup, patients were placed into class I (useful and effective), IIa (evidence favors the procedure), IIb (evidence less well established), or III (not useful and may be harmful) by following the specific text of the guidelines as closely as possible.

### Coding of appropriateness classes.

The criteria for coding appropriateness are summarized in Figure 1. Most patients were classified easily based on readily available clinical data on coronary anatomy, left ventricular function, and the presence of angina. Some patients were more difficult to classify. For example, the guidelines consider patients in the poor left ventricular function group as class III if they are “without evidence of intermittent ischemia and without evidence of significant revascularizable viable myocardium.”

In this study, patients in the poor left ventricular function group were coded as class III by registry data if they did not have: 1) left main disease; 2) proximal left anterior descending artery and circumflex disease; or 3) proximal left anterior descending artery with 2- or 3-vessel disease and who also lacked objective evidence of ischemia. Evidence of ischemia was defined by the results of exercise treadmill testing, nuclear imaging, stress echocardiography, or the presence of unstable angina treated with intravenous nitroglycerin. The issue of whether or not the myocardium was “revascularizable” cannot be assessed easily in the clinical setting or in these data. Individual surgeons must decide whether or not the target lesion can be bypassed.

The class III indications for the stable angina group include: “1. One- or 2-vessel disease not involving
significant proximal LAD stenosis, patients who have mild symptoms that are unlikely to be due to myocardial ischemia or patients who have not received an adequate trial of medical therapy and (a) have only a small area of viable myocardium or (b) have no demonstrable ischemia on noninvasive testing; 2. Borderline coronary stenoses (50% to 60% diameter in locations other than the left main coronary artery) and no demonstrable ischemia on noninvasive testing; 3. Insignificant coronary stenosis (50% diameter reduction) (11).

When data for key elements of the guidelines were missing, we made no assumptions about the missing data and those patients remained unclassified unless they were coded into a class by other criteria. No patient was placed in class III because of missing data.

Statistical methods. Standard statistical methods were used for the calculation of rates and proportions and the chi-square test (13). A nonparametric test of trend across ordered groups was used to identify any significant trend in proportion of class III patients across age groups (14). Statistical significance was defined as a 2-tailed p value <0.05. All analyses were performed using the STATA statistical program (Version 6.0, StataCorp, College Station, Texas).

Results

Appropriateness of CABG procedure. Of the 4,684 patients, we were able to classify 99.6%; 19 (0.4%) could not be unambiguously classified. Largely, these patients could not be placed into appropriateness classes because of missing data on the details of coronary anatomy or on left ventricular ejection fraction. The remaining 4,665 patients were grouped into appropriateness classes: 87.7% were class I, 10.9% were class II (class IIa 8.4% and class IIb 2.5%), and 1.4% were class III (Fig. 2, Table 1). Thus, of the 4,665 CABG procedures, 4,598 (98.6%) were classified as "appropriate" according to the ACC/AHA guidelines for CABG surgery.

Table 1 and Figure 3 describe the appropriateness of CABG surgical procedure by clinical subgroup. Among 56 patients in the clinical subgroup CABG procedure follow-
ing a failed PTCA, 98.2% were class I and 1.8% were class III. Class II indications for CABG following a failed PTCA are for infrequent clinical situations, that is, a foreign body in a crucial anatomic position or hemodynamic compromise with significant impairment of the coagulation system. Among the 233 patients in the ST-segment elevation myocardial infarction subgroup, 99.6% were class I, 0.4% class IIa, and none in class III (there are no described criteria for class IIb). There were 166 patients in the clinical subgroup defined by previous CABG procedure. Among these, 85.5% were class I, 11.5% were class IIa (no class IIb criteria), and 3.0% were class III. Poor left ventricular function was a frequent clinical subgroup for CABG procedure. Among these 874 patients, 71.2% were class I, 23.8% were class IIa, and 5.0% were class III. There is no class IIb indication within this clinical subgroup. Unstable angina/non–ST-segment elevation myocardial infarction was the most frequent clinical subgroup for CABG procedure. Of these 2,294 patients, 93.9% were class I and 6.1% were class II (class IIa = 3.0% and class IIb = 3.1%). There were no class III patients. There were 236 patients with asymptomatic or mild angina as the clinical subgroup for CABG procedure. Among these patients, 77.5% were class I, 22.4% were class II (class IIa = 2.5% and class IIb = 19.9%), and there were no class III patients. Stable angina was a relatively frequent clinical subgroup for CABG procedure. Of these 806 patients, 87.1% were class I, 10.8% were class IIa, and 2.1% were class III. There is no class IIb category for this clinical subgroup.

**Appropriateness by patient sex and age.** The distribution of appropriateness classes for men and women are virtually identical (class I men 87.5%, women 88.2%; class II men 11.2%, women 10.0%; class III men 1.3%, women 1.9%). There was no statistical difference in the distributions (chi-square test with 2 degrees of freedom = 3.32, \( p = 0.190 \)). The appropriateness classes by patient age at surgery showed no significant association between age and class III rates (\( p \) trend = 0.865). There was a trend, however, toward more class I and fewer class II indications with increasing age (\( p \) trend <0.001).

**Clinical subgroup analysis of class III patients.** Of 4,684 patients, 67 were class III. Figure 4 shows the distribution of these patients by clinical subgroups. Patients with poor left ventricular function (65.7% of class III) or stable angina (25.4% of class III) totaled 91% of class III patients. The remaining 9% had either a previous CABG procedure (7.5%) or CABG after a failed PTCA (1.5%).

**Discussion**

We assessed the concordance between the 2004 ACC/AHA Guideline Update for Coronary Artery Bypass Graft Surgery (11) and actual clinical practice in northern New England. Detailed clinical criteria were used to categorize 4,684 isolated CABG procedures performed in 2004 and 2005. The majority of procedures were class I (87.7%), Class II procedures totaled 10.9%, 8.4% were class IIa and 2.5% were class IIb. The remaining 1.4% were class III procedures. Only 19 procedures could not be classified. In these regional data, actual clinical practice closely followed the recommendations of the 2004 ACC/AHA guidelines for CABG surgery (11).

There were some limitations to these analyses and likely some misclassification of patients. The concordance between our regional registry data and the variables required by the ACC/AHA guidelines for CABG surgery was good, but it was not perfect. We were able to classify 99.6% of patients to both a clinical subgroup and to an appropriateness class. The primary reason for being unable to classify a patient was missing data on details of

![Figure 2 ACC/AHA Indications for CABG](image)

Patients were classified using the 2004 ACC/AHA guidelines. Abbreviations as in Figure 1.
coronary anatomy or measurement of left ventricular function. Some variables included in the ACC/AHA guidelines for CABG surgery, such as “quantity of viable myocardium” and “impairment of the coagulation system,” are difficult to interpret and further clarification from the committee would be helpful. Overall, we felt that the ACC/AHA guidelines for CABG surgery included variables that were clinically relevant and the application of the guidelines was straightforward.

There have been several other studies of the appropriateness of CABG surgical procedure. In the mid-1980s, investigators associated with the RAND Corporation and the University of California at Los Angeles developed Delphi panel-based CABG guidelines (12). These guidelines were applied in New York (15), at 3 hospitals in an unidentified western state (12), at academic medical centers (16), and were used to compare cardiovascular care in Canada and New York (17). The RAND investigators found that inappropriate CABG surgery varied from 1.6% at academic medical centers to 14% in the 3 hospitals in 1 western state. Leape et al. (18) randomly selected a group of 676 patients who had CABG procedures in 1991 or 1992. Their medical records were reviewed by the staff of the professional review organizations and a computerized algorithm was used to code the appropriateness class based on the ACC/AHA 1991 Guidelines for Coronary Artery Bypass Graft Surgery (9). They assessed 1.5% of patients to be class III.

This study showed no obvious or statistically significant difference in the appropriateness of cardiac surgery of men and women. Ayanian and Epstein (19) used 1987 data abstracted from 49,623 patients discharged from Massachusetts hospitals and 33,159 patients discharged from Maryland hospitals to study the rates of coronary angiography and CABG procedures. After adjusting for important patient and disease characteristics, they found that women received significantly less coronary angiography than men. These data did not allow them to study the appropriateness of angiography or CABG procedures. Bernstein et al. (20) used retrospective chart review to study the use of cardiovascular procedures among 3,979 patients receiving care during 1990 in 30 New York hospitals. They used the RAND appropriateness score to evaluate the appropriateness of coronary angiography, PTCA, and CABG procedures and compared men and women. The rate of CABG procedures judged to be inappropriate was 2% among men and 3% among women. The current study is in agreement with that of Bernstein et al. (20). If there is a gender-related difference it must occur before the decision to perform cardiac surgery.

Our study of class III patients suggests opportunities for improving clinical decision making. Sixty-six percent of the
class III patients had poor left ventricular function. Coronary artery surgery in these patients should be conditional on establishing the ischemic origin of the cardiomyopathy and the presence of sufficient viable myocardium for successful revascularization to improve pump function. Thallium-201 rest redistribution imaging, positron emission tomography, and dobutamine stress echocardiography have all shown to be good tests for assessing regional myocardial viability (21). Information from these studies should be available when making decisions for patients with depressed ejection fractions. Another group of class III patients were those with stable angina. For these patients, the clinical issue, beyond establishing their coronary anatomy, is proving that the symptoms are due to ischemia from flow-limiting coronary lesions and that these symptoms are not adequately controlled with a reasonable medical regimen. These patients require stress testing to establish the ischemic origin of their pain. When coronary lesions of questionable significance are identified at catheterization, some physiologic assessment of their significance, with a pressure or Doppler wire, would be helpful.

In this study, we used data from consecutive cases from a validated regional registry to assess the appropriateness of CABG procedures based on the 2004 guidelines for CABG surgery (11). This was informative and demonstrated that clinical care closely followed the current ACC/AHA guidelines for CABG surgery. These analyses also identified subgroups of patients (those with poor left ventricular or with stable angina) that are more likely to be class III. This could lead to improved decision making for these patients. However, the real utility of the treatment guidelines lies in their prospective use. We have summarized the appropriateness section of the AHA/ACC 2004 Guideline Update for Coronary Artery Bypass Graft Surgery (Fig. 1). With this tool, it takes only a few minutes to place a patient into a clinical subgroup and to assign an appropriateness class. Evidence-based medicine mandates the constant examination of the appropriateness of invasive procedures. Physicians can and should lead this effort. No one else is as well suited to be a patient’s advocate. The ACC/AHA guidelines for CABG surgery can play an important role in this task. The guidelines provide a synthesis of the current evidence of the effectiveness and appropriateness of this procedure. The prospective use of the guidelines provides for documentation of appropriateness of care in the medical record and discussion of the evidence with the patient. In our view, the routine use of the guidelines benefits the patient, the physician, and the hospital.

References