Adult Coronary Artery Bypass Graft Surgery in the Commonwealth of Massachusetts

Fiscal Year 2012 Report
(October 1, 2011 through September 30, 2012)

Hospital Risk-Standardized 30-Day Mortality Rates

Massachusetts Data Analysis Center
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Harvard Medical School
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February 2014
Updated May 2014

Contracted by the Massachusetts Department of Public Health
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<td>David Shahian, M.D.</td>
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<td>Chairman</td>
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<td>Department of Surgery</td>
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**Interventional Cardiology**

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## Massachusetts Cardiac Surgery Centers

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1 A Message from the Director of the Massachusetts Bureau
of Health Care Safety and Quality

This is the eleventh in a series of reports on risk-standardized, 30-day mortality for the 14 state licensed cardiac surgery programs in the Commonwealth. Risk-standardized 30-day mortality is one of several indicators used to assess quality of care. The report is contracted by the Bureau of Health Care Safety and Quality in the Massachusetts Department of Public Health (the Department). The provision of these data is part of a broad, statewide initiative to increase accessibility of health care data to consumers, policy makers, and providers. This report is meant to give residents information about the relative performance of cardiac surgery programs as an aid to decision making, and to provide hospitals in the Commonwealth with key information to help drive quality improvement.

The Department collects, monitors, and validates patient-specific outcome data from all hospitals that perform cardiac surgery. This report contains analysis of data on 2,680 hospital admissions in which an isolated coronary artery bypass graft (CABG) surgery was performed during the period October 1, 2011 through September 30, 2012. The Massachusetts Data Analysis Center (Mass-DAC) and the Department do not publicly report on surgeon-specific mortality rates. However, data on individual cardiac surgeons are collected and analyzed. After review by a committee of medical experts, information about providers who have higher than expected mortality rates and for whom there are serious concerns about the quality of care that is provided will be shared with the leadership of the hospital department in which that provider operates, and with the Board of Registration in Medicine, the licensing body for physicians.

The data collection, verification, audit, and analytical procedures implemented in this report constitute the most comprehensive, reliable, and rigorous used in the United States. This is due in no small part to the dedicated work of the hospital data managers and cardiac surgeons,
many of whom volunteered their efforts to participate in many late night meetings to review and adjudicate data. I would also like to thank staff from the Board of Registration in Medicine and the Massachusetts Chapter of the Society of Thoracic Surgeons for their ongoing support, and of course, all the staff at Mass-DAC for their hard work and dedication.

Madeleine Biondolillo, M.D.
Associate Commissioner
Director, Bureau of Health Care Safety and Quality
Massachusetts Department of Public Health
2 Key Findings: Hospitals

2.1 Updates

- **May 5, 2014:** Corrected association of Dr. Birjiniuk with Mount Auburn Hospital in committee tables.

2.2 Hospital Findings

- In the period October 1, 2011 through September 30, 2012 (fiscal year 2012), there were 6,696 hospital admissions in Massachusetts in which at least one cardiac surgery was performed.
  - 40.02% (2,680) of the admissions involved isolated coronary artery bypass graft (CABG) surgery.
- In the 14 hospitals that performed cardiac surgery during fiscal year 2012, the number of isolated CABG surgery admissions ranged from 70 to 307.
- The unadjusted 30-day all-cause mortality rate (defined as the number of patients dying from any cause within 30 days of surgery divided by the number of isolated CABG surgery admissions) in Massachusetts during fiscal year 2012 was 1.23%. This corresponded to 33 deaths out of 2,680 isolated CABG admissions.
- After adjusting for patient risk, the risk of 30-day mortality in a hospital one standard deviation above the state average was 1.6 times that of a hospital one standard deviation below the state average.

- **In fiscal year 2012, no hospital was identified as a statistical outlier for isolated coronary artery bypass surgery.**
3 Introduction

3.1 What is in this Report?

This document is the eleventh report (www.massdac.org/reports/surgery.html) describing hospital-specific risk-standardized mortality rates following isolated CABG surgery in Massachusetts. It describes procedures for calculating hospital-specific risk-standardized 30-day mortality rates following isolated coronary artery bypass graft (CABG) surgery performed in Massachusetts hospitals in the period October 1, 2011 through September 30, 2012 (fiscal year 2012). Surgeries performed in federal hospitals (e.g., VA Boston Healthcare System–Jamaica Plain Campus) are not included in this report. Information pertains to patients who were 18 years of age or older at the time of surgery.

Not all hospitals in Massachusetts are permitted to perform cardiac surgery. Hospitals wishing to establish a new cardiac surgery program must submit an application to the Determination of Need Program in the Massachusetts Department of Public Health. In fiscal year 2012, there were 14 cardiac surgery programs in Massachusetts, each of which submitted data to Mass-DAC.

3.2 What is Coronary Artery Bypass Surgery?

For a heart to function properly, it needs an oxygen-rich blood supply. Coronary arteries send oxygen-rich blood to the heart. When the coronary arteries are healthy, blood flows easily so that the heart muscle gets the oxygen it needs. Coronary artery disease begins when blood flow to the heart is reduced due to plaque buildup. Plaque may build up because of high cholesterol, high blood pressure, smoking, diabetes, genetic predisposition, or other factors. As the plaque buildup increases, the coronary arteries narrow and blood flow to the heart is reduced, often leading to angina (chest pain, arm pain, or jaw tightness that occurs with exertion, or in more
serious cases, at rest). If blood flow is completely blocked by the sudden development of a clot within a coronary artery, the presence of the clot usually results in a heart attack or myocardial infarction (MI), which may irreversibly damage the heart muscle.

Coronary artery disease is usually treated by one of three methods: medication, coronary intervention, or cardiac surgery. The choice of treatment depends on the degree of blockage, patient symptoms, and the number of coronary arteries involved. CABG surgery is a type of cardiac surgery that creates a new route or bypass around the blocked part of the artery, allowing the blood flow to reach the heart muscle again. During CABG surgery, the blocked coronary arteries are bypassed using some of the patient’s own blood vessels. The internal mammary arteries are commonly used for the bypass, but the saphenous vein in the leg or the radial artery in the arm can also be used. Surgical procedures in which CABG surgery is the only major heart surgery performed are referred to as isolated CABG procedures.

### 3.3 Definition of Study Population

The patient population includes all patients aged 18 years or older undergoing isolated CABG surgery in Massachusetts adult acute care non-federal hospitals in the period October 1, 2011 through September 30, 2012. If multiple cardiac surgeries occur during an admission, admissions are categorized by the primary (initial) surgery. Isolated CABG surgery includes CABG alone as well as CABG undertaken in combination with the following procedures: maze (closed epicardial approach and radio frequency), pacemaker lead insertions, ventricular lead insertion for automatic implantable cardioverter defibrillator, patent foramen ovale closure, and femoral artery procedures. If CABG is performed in combination with maze (open heart approach), implantation of a cardioverter defibrillator, transmyocardial revascularization, or opening of the right atrium for tumor resection, then these surgeries are classified as “Other Cardiac Surgery.” Lung biopsies performed in conjunction with a CABG are considered on a case by case basis.
(see Appendix A, pg. 45). Table 3.1 lists the distribution of the 6,696 cardiac surgery admissions stratified by surgical procedure type in Massachusetts hospitals during fiscal year 2012.

### 3.4 Why Report on CABG Surgery?

CABG surgeries are costly procedures that account for the majority of cardiac surgeries performed nationally. In fiscal year 2012, isolated CABG surgeries accounted for 40.02% of all cardiac surgery hospital admissions in Massachusetts. Only data on patients who have undergone isolated CABG surgery are used to determine the mortality rates in this report.

### 3.5 What is Mass-DAC?

Mass-DAC is a data-coordinating center responsible to the Massachusetts Department of Public Health for the collection, storage, cleaning, and analysis of the cardiac data submitted by Massachusetts hospitals. Mass-DAC is located in the Department of Health Care Policy within Harvard Medical School in Boston (www.massdac.org). Mass-DAC is advised by several committees on an ongoing basis, including the Massachusetts Cardiac Care Hospital Outlier Committee, the Cardiac Surgery Physician Reporting Committee, and the Cardiac Surgery Data Adjudication Committee. In addition, the national Society of Thoracic Surgeons (STS) and the Massachusetts STS serve as resources.
3.6 Software Utilized in Analysis

The data collection and analysis for this report utilized three different statistical software applications:

- SAS®, versions 9.3/9.4 Unix/Windows [5];

- WinBUGS version 1.4 [9];

- R version 3.0 [4].

The data collection process utilized Base SAS to aggregate the core data elements for the analytic data sets. The statistical analysis used a combination of SAS/STAT, WinBUGS, and R to generate the results in this report. SAS Institute Inc. and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc., Cary, NC, USA.
4 Summary of Data Collection and Verification Procedures

4.1 Definition of Patient Outcome

Mortality, regardless of cause and measured within 30 days of the date of CABG surgery, is the primary patient outcome. Mortality was selected as the primary measure of quality because it is serious and unambiguous.

4.2 Massachusetts Cardiac Surgery Programs

Fourteen cardiac surgery centers treated patients in Massachusetts in the period October 1, 2011 through September 30, 2012.

4.3 Data Sources

Four different data sources were used to create this report:

- The Mass-DAC cardiac surgery patient-specific data collected using the Society of Thoracic Surgeons (STS) National Cardiac Surgery data collection tool version 2.73 [8, 7];

- Acute Hospital Case Mix Databases [2] from the Massachusetts Center for Health Information and Analysis;

- Vital records information [3] from the Massachusetts Registry of Vital Records and Statistics; and

- The Mass-DAC PCI database with data collected using the American College of Cardiology–National Cardiovascular Data Registry (ACC-NCDR–CathPCI) data collection tool [1].
4.3.1 Mass-DAC STS Data

Patient-specific risk factor and outcome data were collected by hospital personnel using version 2.73 of the STS National Cardiac Surgery data collection tool (see Appendix B), containing 788 variables.

4.3.2 Massachusetts Acute Hospital Case Mix Database

Hospital inpatient discharge data for fiscal years 2002 through 2012 (October 1, 2001 through September 30, 2012) were obtained from the Massachusetts Center for Health Information and Analysis. Data elements include hospital identifier, sex, race, age, patient’s zip code, up to 15 diagnoses and up to 15 procedure codes, discharge status, dates of admission and discharge, date of surgery, and patient medical record number. Social Security numbers are encrypted in this database. Data were used for validation of surgery volume.

4.3.3 Massachusetts Registry of Vital Records

Death date information obtained from Massachusetts Registry of Vital Records and Statistics was available for deaths occurring in Massachusetts between January 1, 2002, and October 30, 2012. While the primary source of 30-day mortality was the hospital-reported information, the mortality index database was employed as a verification tool. Using a confidential and secure transmission procedure, Mass-DAC submitted to the Registry, patient names, dates of birth, and Social Security numbers for all Mass-DAC patients, regardless of hospital-reported survival status. Registry personnel subsequently linked the data submitted by Mass-DAC to the Registry mortality index database using these variables and supplied Mass-DAC with the date of death for all applicable patients.
4.4 Mass-DAC Data Collection Procedures

The majority of Massachusetts hospitals used clinical staff, such as physicians, nurses, and perfusionists, to collect information. Data were entered directly into the STS vendor software database by the clinical staff or by a data manager. Alternatively, the data manager collected the STS information under the direction of clinical staff and then entered the data following a retrospective chart review. Data managers were also responsible for maintaining their hospital database, ensuring the accuracy of the data, and transmitting data to both the STS and Mass-DAC.

Data were regularly transmitted by hospitals and harvested by Mass-DAC (Table 4.1). This process involved submitting protected data during specific harvest periods. Hospitals encrypted and password-protected the data, and transmitted it electronically using a secure repository on a secure website. Hospitals submitted subsequent corrected data as often as desired during the three months following a harvest, and they could sign off on its accuracy and completeness at any time during that period. However, all fiscal year 2012 cardiac surgery data were required to be complete by April 1, 2013, after which no changes were accepted without written permission from Mass-DAC.

Table 4.1: Fiscal Year 2012 Cardiac Surgery Data Harvest Schedule

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<th>Harvest Month</th>
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<td>September 2012</td>
<td>April 1, 2012–June 30, 2012</td>
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<td>April 2013</td>
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4.5 Cleaning and Validation Procedures

Hospital data submissions were cleaned and verified using a variety of procedures, including continuous feedback via ongoing data quality reports, meetings and communication, and reviews of concordance with administrative datasets and medical chart audits.

4.5.1 Hospital-Specific Data Quality Reports

For each data submission, Mass-DAC provided a data quality report to each hospital describing the distribution of all STS variables and identifying cases with missing, out of usual range, or inconsistent coding. The hospitals were given 30 days to correct the data deficiencies identified by Mass-DAC following receipt of each data quality report. There were a total of 156 data submissions sent by 14 hospitals during fiscal year 2012 with a mean of 2.79 submissions per hospital per collection period. Data submissions for fiscal year 2012 ranged from 1 to 7 per hospital per collection period.

4.5.2 Massachusetts Administrative Datasets

Mass-DAC found high agreement between the hospital report of 30-day mortality and information linked to Massachusetts vital records. After verifying the mortality status of these patients, five cases were changed to 30-day mortalities, one of which was an isolated CABG patient.

The Massachusetts inpatient case mix data was used as an additional method in determining whether all appropriate cases of cardiac surgery from each institution were submitted to Mass-DAC. Two cases were found in the case mix data that had not been submitted to the Mass-DAC database. The two cases were confirmed with each hospital and their data submitted and subsequently included in the Mass-DAC database. Neither of the two cases were isolated CABGs.
4.5.3 Meetings and Communication

Mass-DAC communicated regularly via email and telephone with the data managers to clarify definitions or procedural issues, resolve data submission concerns, and to serve as a facilitator to the national STS. Data managers were given the opportunity to ask and discuss questions at data manager meetings or through an email network. Results were shared at the Mass-DAC Data Manager meetings. This process helped identify areas where data may be inconsistent, incorrectly coded, or outlying.

4.5.4 Audit Data

In the spring and again in the fall of 2013, a sample of the fiscal year 2012 isolated CABG data was audited. Twelve cardiac surgeons and four data managers, representing 10 of the 14 cardiac surgery programs, volunteered for the Adjudication Committee to perform audits. Records requested from the hospitals included those for:

1. All isolated coronary artery bypass graft (CABG) patients coded as a death within 30 days of surgery;
2. All isolated CABG patients coded as having shock prior to surgery;
3. All isolated CABG patients coded with emergent or emergent salvage status;
4. All isolated CABG patients coded as having peripheral vascular disease (PVD) as a risk factor;
5. Those admissions coded as having an “other” cardiac procedure in combination with isolated CABG (to determine if those should have been coded as an isolated CABG) and resulting in death within 30 days of surgery.
For the variable audit, 527 records were requested from the 14 hospitals. The records were reviewed to determine data consistency and accuracy of coding. A total of 86 variable coding changes were made.

For the procedure audit, 75 records were requested. The procedure audit records included a subset of surgery admissions having \textit{CABG + other}, (see Appendix A, pg. 45, Procedure Identification Guidelines for Adult Cardiac Surgery, which outlines the rules used by Mass-DAC for classifying surgeries as isolated CABG versus \textit{CABG + other}). These records were reviewed for the procedure audit to determine if some might be considered isolated CABG surgery. Documentation requested from the hospitals included discharge summaries, operative reports, anesthesia records, admission and history summaries, and catheterization reports. Records that were reviewed and subsequently identified by the auditors to be isolated CABG procedures were then also reviewed for the variables of shock, emergent or emergent salvage status, and PVD. A total of 31 \textit{CABG + other} codings were changed to \textit{isolated CABG}.

In all, 574 records (28 in both the variable and procedure audits) were reviewed by the Adjudication Committee to determine agreement with the information submitted by the hospitals. If the Adjudication Committee did not agree with the coding of the presence of shock, emergent status, emergent salvage status, PVD, or procedure type of \textit{CABG + other}, the coding was changed. Hospitals were notified of any disagreement in coding and given an opportunity to appeal the Adjudication Committee decisions. All coding changes made by the Adjudication Committee were then implemented in the Mass-DAC database.
5 Risk Adjustment

5.1 Who Receives Isolated CABG Surgery in Massachusetts?

Table 5.1 on page 15 lists the age/sex/race distribution for 2,680 adult isolated CABG surgery patients at 14 cardiac surgery programs in Massachusetts. The STS data collection tool allows patients to be identified with more than one race; in addition, Hispanic is an ethnicity choice and is separate from the race designations. Patients not selecting any race designation are defined as “other race.” The majority of patients were male (77.9%). In fiscal year 2012, 57.1% of the admissions corresponded to patients aged 65 years of age or older at the time of surgery. Patients who resided outside of Massachusetts at the time of surgery comprised 9.7% of the 2,680 isolated CABG admissions (data not shown).

5.2 Risk Adjustment for Assessing Hospital Mortality

Specific risk factors are known to contribute to heart disease. These risk factors include high cholesterol, smoking, high blood pressure, family history of heart disease, diabetes, age, sex, and general health status. Such factors have an impact on the risk of mortality following CABG surgery. Sicker patients or patients with more health-related risks may be more likely to die following a CABG surgery than healthier patients. Moreover, patients who are sicker may be more likely to be treated at particular hospitals while patients who are healthier may be more likely to be treated at other hospitals. To fairly assess hospitals and avoid penalizing hospitals that treat sicker patients, it is important to consider differences in a patient’s health prior to surgery. Mass-DAC selects risk factors for the annual report based on advice obtained from its Senior Medical Advisors, Mass-DAC surgeon committees, as well as the Massachusetts STS.
Table 5.1: Demographic Distribution for All Adult Isolated CABG Surgery Admissions (N = 2,680) in Massachusetts Hospitals: Oct 1, 2011–Sep 30, 2012.

Note: Entries are counts. Patients may select more than one race category. The Hispanic Ethnicity category is independent of the race categories and may be selected in addition to a race.

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<td></td>
</tr>
<tr>
<td>≥75</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Frequencies from 1 to 10 and frequencies enabling one to determine a frequency between 1 and 10 are suppressed as required by the Massachusetts Department of Public Health data security guidelines.

The statistical process of accounting for differences in patient sickness prior to surgery is called risk adjustment. This statistical process aims to “level the playing field” by accounting for health risks that patients have prior to surgery. The hospital-specific 30-day mortality rates in this report have been adjusted in order to account for patient health prior to surgery. The numbers
reported compare each hospital’s mortality rate to what would be expected to happen given the health of patients undergoing surgery in its program. The numbers are not designed to provide comparisons between pairs of hospitals—such comparisons would only be valid to the extent that the pairs of hospitals treated patients with very similar health status prior to surgery.

### 5.3 How are Hospital Differences in Patient Outcomes Measured?

If there are differences in hospital quality, due to staff, experience, or other factors, then the risks of 30-day mortality for two patients having exactly the same risk factors prior to a CABG surgery but who are treated in different hospitals should be different. The statistical model used to calculate mortality rates in this report, a hierarchical Poisson regression model, permits a difference to exist between the risks of mortality for patients with the same risk factors treated at different hospitals. This is accomplished by including a hospital-specific (random) effect. If no key risk factor that varies by hospital is missing from the statistical model, then the hospital-specific random effect represents quality for each hospital. If there are no differences in the hospital-specific effects across the hospitals, then there is no evidence of quality differences.
6 Identifying Outlying Cardiac Surgery Programs

One of the purposes of this report is to identify hospitals that have unusually high or unusually low mortality rates. Such hospitals are denoted as “outlying”—however, the designation of outlying depends on how large the difference is. Two methods are used to identify outlying hospitals. The first method calculates a 95% interval estimate for each hospital’s risk-standardized mortality rate. If the interval estimate excludes the Massachusetts unadjusted 30-day mortality rate, the hospital is designated as “outlying.”

Because any one hospital could influence the estimates of the risk-standardized mortality rate for other hospitals, Mass-DAC also calculates the expected number of mortalities at each hospital using the experience of all other hospitals in Massachusetts. If it is unlikely that the actual number of mortalities observed at a hospital and the number of mortalities predicted using the combined experience of all Massachusetts hospitals except the hospital under study is the same, then the hospital is classified as “outlying.” We refer to the measure of the likelihood of this event as a cross-validated p-value. Intuitively, this strategy provides a quantitative measure of how likely the hospital’s outcome is compared to its peers – the smaller the "p-value", the less likely it is like its peers.

If (1) the 95% interval estimate for a particular hospital excludes the Massachusetts unadjusted 30-day mortality rate or (2) the probability of the observed mortality predicted from all other hospitals for a particular hospital is small, then the hospital is designated as outlying. It is important to note that the classification in this report is relative to all hospitals in Massachusetts performing isolated CABG surgery. For example, a Massachusetts hospital identified as having higher (or lower) than expected mortality based on our analysis may not be classified as having higher (or lower) than expected mortality compared to hospitals outside of Massachusetts.
6.1 Standardized Mortality Incidence Rates (SMIR)

Mass-DAC calculated a standardized mortality incidence rate (SMIR) and a corresponding 95% posterior interval for each hospital. The SMIR is interpreted as the projected mortality rate at the hospital today if hospital quality remained the same as in fiscal year 2012. The SMIR consists of an estimate of the hospital’s underlying (true) risk-adjusted rate divided by an estimate of the mortality rate expected at the hospital given its case mix. Each hospital’s SMIR should only be interpreted in the context of its interval. If the 95% interval includes the unadjusted Massachusetts mortality rate, then the hospital mortality is not different than expected. If the interval excludes the Massachusetts unadjusted rate, then the hospital is an outlier. In this case, if the upper limit of the interval is lower than the unadjusted Massachusetts rate, then fewer patients than expected died. Such a hospital would be categorized as having lower than expected mortality. If the lower limit of the interval is higher than the Massachusetts unadjusted rate, then more patients than expected died. Such a hospital would be categorized as having higher than expected mortality.

Hospital-specific 30-day mortality rates, standardized to the population of adults undergoing isolated CABG surgery in Massachusetts hospitals, were calculated using the following procedure:

1. A hierarchical Poisson regression model was estimated that assumes the log of 30-day mortality is related linearly to the set of risk factors and permits baseline risk to vary across hospitals. Let $Y_{ij} = 1$ if the $j^{th}$ patient treated at the $i^{th}$ CABG hospital died within 30 days of CABG surgery and 0 otherwise, and let $n_i$ equal the total number of CABG surgery admissions at the hospital. The model estimated had the general form:

$$\log[Probability(Y_{ij} = 1)] = \beta_{0i} + \beta(\text{Risk Factors})_{ij}$$

where $$\beta_{0i} \sim \text{Normal}(\mu, \tau^2)$$

(1)

(2)
The parameters, $\mu$ and $\tau^2$ represent the overall mean risk-adjusted log of mortality and between-hospital variation, respectively. If there are no mortality differences based on 30-day mortality across the 14 CABG surgery hospitals after adjusting for patient risk, then

$$\beta_{0,1} = \beta_{0,2} = \cdots = \beta_{0,14} = \beta_0$$

and this happens if and only if $\tau^2 = 0$ (3)

The hierarchical regression models were estimated using WinBUGS software. The prior distributions assumed for $\beta$, $\mu$, and $\tau^2$ were, respectively: independent normal distributions with mean 0 and variance 1,000 for the components of $\beta$; $\mu$ from a normal distribution with mean 0 and variance 1,000. We assumed that between-hospital standard deviation, $\tau$, arose from a half normal distribution with mean 0 and variance 0.26. This half normal distribution has its mode at 0, permitting no differences in between-hospital log-odds of mortality, but has a median of 0.39, permitting the range in the log-odds of 30-day mortality to be as large as 5. We vary these parameters as part of a sensitivity analysis. A burn-in of 100,000 draws was used and conclusions were based on an additional 5,000 draws. Convergence of the model was assessed using the Gelman-Rubin statistic via three parallel chains.

2. The risk factors are those listed in Table 7.1. The term $\beta$ describes the association of each risk factor and $\log(30\text{-day mortality})$. Large values of $\beta$ indicate that patients with the particular risk factor are at higher risk of dying compared to patients without the risk factor.
3. The *expected* mortality rate at hospital $i$, $\pi_i$, is:

$$\pi_i = \frac{\sum_{j=1}^{n_i} \exp[\mu + \beta(Risk\ Factors)_{ij}]}{n_i}$$ (4)

This is the mortality rate expected at hospital $i$ using the mortality intensity for the entire state, $\beta$, and the case mix reported at the hospital, $(Risk\ Factors)_{ij}$. Thus, it represents the severity of cases at the institution.

4. The *observed* mortality rate at hospital $i$, $p_i$, is:

$$p_i = \frac{\sum_{j=1}^{n_i} \exp[\beta_0i + \beta(Risk\ Factors)_{ij}]}{n_i}$$ (5)

This is interpreted as the mortality rate at the $i^{th}$ hospital adjusted for case mix. This mortality rate is not the actual observed rate but rather a *smoothed* rate. The estimate weights the observed mortality rate by the amount of information available at the hospital relative to the amount of information available between hospitals. Because the model assumes that the probability of dying is greater than 0, the smoothed estimate must be greater than 0.

5. The Massachusetts unadjusted 30-day mortality rate is:

$$\bar{Y} = 100 \times \frac{\sum_{ij} Y_{ij}}{\sum_{i} n_i}$$ (6)

6. The standardized mortality incidence rate (SMIR) at institution $i$ is:

$$SMIR_i = \frac{\bar{Y}}{\pi_i} \times \frac{p_i}{\pi_i}$$ (7)

The SMIR is interpreted as the projected mortality rate at the hospital today if hospital quality remained the same as in fiscal year 2012.

7. Ninety-five percent posterior intervals were calculated for each hospital’s SMIR.
6.2 Cross-Validated P-Values

Because data from all hospitals are used to estimate the expected number of deaths in any hospital and because the number of CABG hospitals in Massachusetts is small, there is a risk that outlying hospitals may influence the estimates of $\mu$ and, in particular, $\tau^2$. One method to avoid this risk involves identifying hospitals as outlying through “cross-validation”. This process involves systematically dropping each hospital from the data set and re-estimating the risk-adjusted model. Using the new model, the predicted number of deaths at the dropped hospital is calculated. This predicted number may be interpreted as the number of mortalities expected at the dropped hospital if the dropped hospital had the same level of quality as the remaining Massachusetts hospitals.

Mass-DAC compared the predicted number of deaths to the actual number of deaths at the dropped hospital and calculated a posterior probability. This probability, loosely called a posterior “p-value,” quantifies how likely the observed number of deaths would be if the dropped hospital had the same level of quality as all remaining isolated CABG hospitals. Small p-values (those $\leq 0.01$) indicate that the dropped hospital is outlying. When the p-value is small and the actual number of deaths is larger than that predicted by the remaining hospitals, the dropped hospital is classified as having higher than predicted mortality. When the p-value is small and the actual number of deaths is smaller than predicted by its peers, then the hospital is classified as having lower than predicted mortality. Mass-DAC eliminated each isolated CABG hospital from the data set, re-estimated the regression parameters, predicted mortality at the eliminated hospital, and calculated a posterior probability of the comparison of the observed mortality and the predicted mortality. The eliminated hospital was replaced into the data set, and Mass-DAC eliminated another hospital from the data set, repeating the entire process.
6.3 Sensitivity Analyses

Several sensitivity analyses were undertaken to determine whether conclusions would change when making reasonable changes to some of the underlying assumptions. A key assumption, given the small number of hospitals in Massachusetts, is the assumed distribution for the between-hospital variance. The parameter $\tau$ represents the standard deviation of the hospital-specific risk-adjusted log(mortality) and $\tau^2$ represents between-hospital variance. The main analyses assumed that $\tau$ arose from a half normal distribution with mean 0 and variance 0.26. Mass-DAC re-estimated the hierarchical model using different prior distributions for $\tau^2$ to determine how sensitive results are to the assumed prior distribution of the variance component.

1. We assumed that the between-hospital standard deviation arose from a uniform distribution over the range 0 to 1.5. This translates to assuming that small values in between-hospital heterogeneity are just as likely as large values.

2. We assumed a vague prior distribution for the precision, $\frac{1}{\tau^2}$. Specifically, we assumed the precision parameter arose from a highly dispersed Gamma distribution having scale parameter 0.001 and rate parameter 0.001.
7 Hospital Quality Following Isolated CABG Surgery

Of the 2,680 isolated CABG surgery admissions in fiscal year 2012 in Massachusetts, 33 patients (1.23%) died within 30 days of their surgery. Table 7.1 lists the prevalence (as a percentage) of important risk factors and the relationship of each risk factor (controlling for all other risk factors) to 30-day mortality following surgery. For example, 1.38% of the 2,680 isolated CABG surgery admissions were associated with patients who had a prior CABG surgery. Relative risks greater than 1 correspond to increased risk of mortality while those less than 1 correspond to decreased risk of mortality. The relative risk of 12.98 for those having a prior CABG surgery indicates that those with such a history are almost 13 times as likely as those not having a prior CABG surgery to die within 30 days of CABG surgery. Patients coded in cardiogenic shock prior to isolated CABG surgery are 5.38 times more likely to die within 30 days than patients not coded as in cardiogenic shock. Because age is measured in years, the table reports the average number of years over age 65 for the cohort.

The estimate of between-hospital variation after adjusting for patient case mix is 0.061. This may be interpreted as indicating that the risk of dying if admitted to a Massachusetts cardiac surgery program one standard deviation above the state mean is 1.6 times that of dying if admitted to a program one standard deviation below the state mean. The estimated area under the ROC curve is 0.72 (Figure 7.1).
Table 7.1: Prevalences and Relative Risks of 30-Day Mortality Following Isolated CABG Surgery in Adults: Oct 1, 2011–Sep 30, 2012. Based on 2,680 surgeries with 33 deaths (1.23%).

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Prevalence (%)</th>
<th>Relative Risk</th>
<th>95% Interval for Relative Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age in Years over 65</td>
<td>1.08&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.02</td>
<td>(0.98, 1.06)</td>
</tr>
<tr>
<td>Renal Failure–Dialysis</td>
<td>1.68</td>
<td>3.71</td>
<td>(0.68, 10.00)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>43.43</td>
<td>1.51</td>
<td>(0.70, 2.85)</td>
</tr>
<tr>
<td>Prior CABG Surgery</td>
<td>1.38</td>
<td>12.98</td>
<td>(3.85, 28.52)</td>
</tr>
<tr>
<td>Cardiogenic Shock</td>
<td>0.49</td>
<td>5.38</td>
<td>(0.30, 24.12)</td>
</tr>
<tr>
<td>Ejection Fraction (Ref: (\geq 30) and missing)</td>
<td>94.48</td>
<td>1.00</td>
<td>—</td>
</tr>
<tr>
<td>Less than 30%</td>
<td>5.52</td>
<td>2.18</td>
<td>(0.57, 5.09)</td>
</tr>
<tr>
<td>Status of CABG (Ref=Elective)</td>
<td>37.02</td>
<td>1.00</td>
<td>—</td>
</tr>
<tr>
<td>Urgent</td>
<td>60.52</td>
<td>1.35</td>
<td>(0.60, 2.67)</td>
</tr>
<tr>
<td>Emergent or Emergent Salvage</td>
<td>2.46</td>
<td>3.95</td>
<td>(0.50, 11.88)</td>
</tr>
</tbody>
</table>

**Between-Hospital Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean</th>
<th>95% Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between-Hospital Average log, (\mu)</td>
<td>-5.21</td>
<td>(-5.89, -4.54)</td>
</tr>
<tr>
<td>Between-Hospital Variance&lt;sup&gt;b&lt;/sup&gt; in logs, (\tau^2)</td>
<td>0.0611</td>
<td>(8.428 (\times) 10(^{-5}), 0.338)</td>
</tr>
</tbody>
</table>

<sup>a</sup>Average age of patients undergoing isolated CABG surgery is 65 + 1.08 = 66.08 years of age. For age, the mean is used instead of prevalence because age is continuous and not categorical.

<sup>b</sup>The between-hospital variance may be roughly interpreted as saying that the odds of dying when treated by a hospital one standard deviation below average quality is 1.6 times that when treated by a hospital one standard deviation above average quality.
Figure 7.2: Model Covariate Summaries, by Hospital Oct 1, 2011–Sep 30, 2012.

Each point corresponds to a Massachusetts CABG hospital. Hospitals sorted from lowest value to highest value.
Figure 7.3: Ninety-Five Percent Posterior Intervals for Standardized 30-Day Mortality Incidence Rates (SMIRs) Following Isolated CABG Surgery in Massachusetts: Oct 1, 2011–Sep 30, 2012

# of cases refers to the number of isolated CABG surgery admissions; expected mortality is the percentage of cases expected to die given the case mix of the patients treated in the hospital. The white vertical line in each box is the hospital’s SMIR while the black vertical line denotes the unadjusted Massachusetts 30-day mortality rate of 1.23%.

HOSPITAL KEY:
B&W = Brigham and Women’s Hospital; BIDMC = Beth Israel Deaconess Medical Center; BMC = Boston Medical Center;
Baystate = Baystate Medical Center; Cape Cod = Cape Cod Hospital; Charlton = Southcoast Hospital Group–Charlton Memorial Hospital;
Lahey = Lahey Hospital & Medical Center; MGH = Massachusetts General Hospital; Mt. Auburn = Mount Auburn Hospital; Salem = North Shore Medical Center–Salem Hospital; St. Elizabeth’s = Saint Elizabeth’s Medical Center; St. Vincent = Saint Vincent Hospital; TMC = Tufts Medical Center; UMass = UMass Memorial Medical Center.
Figure 7.2 on page 25 displays the model covariate summaries by hospital. The red horizontal line on each chart is the Massachusetts state average (prevalences) shown in Table 7.1 on page 24. Each chart point represents one of the 14 cardiac surgery programs and is sorted from lowest to highest prevalence for each covariate. For example, the figure indicates that in one hospital about 1% of its isolated CABG cases had ejection fractions less than 30% and another hospital had about 10% of its isolated CABG cases with ejection fractions less than 30%.

Figure 7.3 on page 26 displays the SMIRs and corresponding 95% posterior intervals. The solid black vertical line in the figure is the unadjusted state 30-day mortality rate of 1.23%. Listed on the left-hand side of the figure are the total number of isolated CABG surgery admissions and the expected 30-day mortality rates for each hospital. The expected mortality rate provides an overall assessment of case mix severity at each program. Increasing values of the expected 30-day mortality rates correspond to increasing admission severity. Listed on the right-hand side are the estimated SMIRs. All 95% posterior intervals (horizontal boxes) include the unadjusted Massachusetts rate of 1.23%.

Figure 7.4 on page 28 graphically depicts within and between-hospital differences in risk of isolated CABG cases treated in fiscal year 2012. We multiplied the risk factors for each hospital’s CABG case observed in 2012 by the regression coefficients estimated in the prior year’s report, summed this quantity within a case, and converted it to a probability. This probability represents the predicted risk of 30-day mortality. We then summarized the distribution of these predicted probabilities within each hospital. This was accomplished using a density estimator. For each CABG hospital in the figure, the number of isolated CABG cases relative to its total number of CABG cases is plotted against the "severity" (the predicted probability multiplied by 100) of its cases. Hospitals having long right tails correspond to those predicted to have treated sicker patients.
Figure 7.4: Case-Mix Severity, by Hospital Oct 1, 2011–Sep 30, 2012.

The x-axis depicts the predicted risk (multiplied by 100) of dying 30-days after isolated CABG surgery and the y-axis represents the relative number of isolated CABG surgery admissions at the predicted risk.

HOSPITAL KEY:
B&W = Brigham and Women’s Hospital; BIDMC = Beth Israel Deaconess Medical Center; BMC = Boston Medical Center; Baystate = Baystate Medical Center; Cape Cod = Cape Cod Hospital; Charlton = Southcoast Hospital Group–Charlton Memorial Hospital; Lahey = Lahey Hospital & Medical Center; MGH = Massachusetts General Hospital; Mt. Auburn = Mount Auburn Hospital; Salem = North Shore Medical Center–Salem Hospital; St. Elizabeth’s = Saint Elizabeth’s Medical Center; St. Vincent = Saint Vincent Hospital; TMC = Tufts Medical Center; UMass = UMass Memorial Medical Center.
Figure 7.5: Cross-Validated P-Values: Isolated Cardiac Surgery Admissions

Posterior probabilities (p-values) of observed with predicted mortality for each of the 14 cardiac surgery programs are listed on the y-axis; the x-axis identifies the hospital.

HOSPITAL KEY:
B&W = Brigham and Women’s Hospital; BIDMC = Beth Israel Deaconess Medical Center; BMC = Boston Medical Center;
Baystate = Baystate Medical Center; Cape Cod = Cape Cod Hospital; Charlton = Southcoast Hospital Group–Charlton Memorial Hospital;
Lahey = Lahey Hospital & Medical Center; MGH = Massachusetts General Hospital; Mt. Auburn = Mount Auburn Hospital; Salem = North Shore Medical Center–Salem Hospital; St. Elizabeth’s = Saint Elizabeth’s Medical Center; St. Vincent = Saint Vincent Hospital; TMC = Tufts Medical Center; UMass = UMass Memorial Medical Center.
Figure 7.5 on page 29 presents the cross-validated posterior probabilities (p-values) where the reference line on the graph at 0.01 indicates the cutoff for outliers based on the p-value. Any hospital with a bar entirely under this line is considered to be different than predicted. The cross validated p-values indicate that there were no cardiac surgery program outliers in fiscal year 2012.
8 Annual Hospital 30-Day Mortality Trends Following Isolated CABG Surgery Jan 1, 2002–Sep 30, 2012

8.1 Key Changes in Reporting

- FY 2006:
  1. Cohorts analyzed over a fiscal year October–September instead of a calendar year January–December;
  2. The number of categories for the MI variable was reduced from five to three in the hospital model.

- FY 2007:
  1. Admissions coded with shock, emergent status, or emergent salvage status were removed from the surgeon cohort.

- FY 2008:
  1. Renal failure was replaced with dialysis as a risk factor;
  2. Patients for whom ejection fraction (EF) was not done or its value missing were included with the reference group in the model, while the model variable EF<30 or missing or not done was changed to EF<30;
  3. Intra-aortic balloon pump was removed from the model.
• FY 2009:

1. The number of categories for the MI variables was reduced from three to two in the surgeon model.

• FY 2010:

1. The number of covariates in both the hospital and surgeon models were reduced by eliminating the following:
   - Male;
   - Hypertension;
   - Prior PCI;
   - Ejection fraction 30-39%;
   - Myocardial infarction >24 hours.

2. The categories describing timing of myocardial infarction (MI) combined within 6 hours and 7-24 hours to the category MI within 24 hours;

3. The model changed from a hierarchical logistic–normal regression to a Poisson–normal regression.

• FY 2011:

1. The number of covariates in the model was reduced, eliminating myocardial infarction within 24 hours;

2. Suspended public reporting of individual surgeons to be consistent with the Massachusetts reporting for interventional cardiologists performing percutaneous coronary interventions. Data will continued to be collected and analyzed.
FY 2012:

1. The number of covariates in the model was reduced, eliminating peripheral vascular disease.
Table 8.1: Summary of Isolated CABG Admissions and 30-Day Crude Mortality Percentages CY 2002 through FY 2012

<table>
<thead>
<tr>
<th>Year of Surgery</th>
<th>Number of Hospitals</th>
<th>Number of Admissions</th>
<th>30-Day Crude Mortality (%)</th>
<th>Between-Hospital Variance in Log-Odds of Mortality</th>
<th>Between-Hospital Standard Deviation in SMIRS (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CY 2002</td>
<td>13</td>
<td>4,603</td>
<td>2.19</td>
<td>0.042</td>
<td>0.13</td>
</tr>
<tr>
<td>CY 2003</td>
<td>14</td>
<td>4,393</td>
<td>2.25</td>
<td>0.094</td>
<td>0.29</td>
</tr>
<tr>
<td>CY 2004</td>
<td>14</td>
<td>3,986</td>
<td>2.01</td>
<td>0.349</td>
<td>0.72</td>
</tr>
<tr>
<td>CY 2005</td>
<td>14</td>
<td>3,883</td>
<td>1.65</td>
<td>0.130</td>
<td>0.31</td>
</tr>
<tr>
<td>FY 2006</td>
<td>14</td>
<td>3,684</td>
<td>1.41</td>
<td>0.035</td>
<td>0.045</td>
</tr>
<tr>
<td>FY 2007</td>
<td>14</td>
<td>3,396</td>
<td>1.47</td>
<td>0.389</td>
<td>0.580</td>
</tr>
<tr>
<td>FY 2008</td>
<td>14</td>
<td>3,336</td>
<td>1.38</td>
<td>0.049</td>
<td>0.069</td>
</tr>
<tr>
<td>FY 2009</td>
<td>14</td>
<td>3,284</td>
<td>1.19</td>
<td>0.049</td>
<td>0.054</td>
</tr>
<tr>
<td>FY 2010</td>
<td>14</td>
<td>3,169</td>
<td>1.23</td>
<td>0.067</td>
<td>0.066</td>
</tr>
<tr>
<td>FY 2011</td>
<td>14</td>
<td>2,840</td>
<td>0.99</td>
<td>0.226</td>
<td>0.208</td>
</tr>
<tr>
<td>FY 2012</td>
<td>14</td>
<td>2,680</td>
<td>1.23</td>
<td>0.061</td>
<td>0.059</td>
</tr>
</tbody>
</table>

CY denotes calendar year (Jan-Dec); FY denotes fiscal year (Oct-Sep).
9 Important Definitions

STS version 2.73 was used for data collection for surgeries from October 2011 through September 30, 2012. Many of the definitions used in this section were extracted from the STS Adult Cardiac Data Specifications, version 2.73.[7]

Admissions: Refers to a single episode of care at one facility from the date of admission to the date of discharge.

Aortic Valve Repair: Surgical repair of the aortic valve of the heart. The aortic valve is responsible for facilitating the flow of blood into the aorta.

Aortic Valve Replacement (AVR): A surgical procedure involving replacement of the aortic valve of the heart.

Cardiac Catheterization: A procedure that determines the extent and the location of the coronary artery obstruction or blockage.

Cardiac Surgery: Surgery on the heart and the thoracic great vessels. Examples of cardiac surgery include coronary artery bypass grafts, heart valve repair or replacement, heart transplantation, surgery of the thoracic aorta, repair of congenital heart defects, and minimally invasive heart surgery.

Cardiogenic Shock: Indicate whether the patient was, at the time of procedure, in a clinical state of end organ hypoperfusion due to cardiac failure according to the following criteria:

a. persistent hypotension (Systolic BP <80-90 or mean arterial pressure 30 mmhg lower than baseline) and

b. severe reduction in Cardiac Index (<1.8 without support or <2.2 with support).
Cardiovascular Disease: Includes diseases of the heart or vessels that supply the body and the heart muscle with blood and oxygen.

Coronary Artery Disease: A disease affecting the coronary arteries in which the flow of oxygen-containing blood to the heart muscle is partially or completely blocked, resulting in angina or a heart attack.

Coronary Artery Bypass Graft (CABG) Surgery: An operation in which the blocked coronary vessels are bypassed with the patient’s own vessels to improve flow to the heart muscle. Coronary vessels are those vessels that supply the heart muscle with blood and oxygen.

Cross-Validation: Model validation is done to ascertain whether predicted values from a statistical model are likely to accurately predict responses on future subjects or on subjects not used to develop the analytical model. Cross-validation involves dropping a set of observations from the analytical process and the outcomes for the dropped set are predicted. This process is repeated many times in order to characterize the accuracy of the predictions.

Diabetes: Indicate whether patient has a history of diabetes diagnosed and/or treated by a physician. The American Diabetes Association criteria include documentation of the following:

a. A1c ≥ 6.5%; or

b. Fasting plasma glucose ≥ 126 mg/dl (7.0 mmol/l); or

c. Two-hour plasma glucose ≥ 200 mg/dl (11.1 mmol/l) during an oral glucose tolerance test; or

d. In a patient with classic symptoms of hyperglycemia or hyperglycemic crisis, a random plasma glucose ≥ 200 mg/dl (11.1 mmol/l). It does not include gestational diabetes.

Dialysis: Indicates whether the patient is currently undergoing dialysis.
**Ejection Fraction:** Indicates the percentage of the blood emptied from the ventricle at the end of the contraction.

**Myocardial Infarction (MI):** Indicate if the patient has a history of MI. A myocardial infarction is evidenced by any of the following:

a. A rise and fall of cardiac biomarkers (preferably troponin) with at least one of the values in the abnormal range for that laboratory [typically above the 99th percentile of the upper reference limit (URL) for normal subjects] together with at least one of the following manifestations of myocardial ischemia:

1. Ischemic symptoms;
2. ECG changes indicative of new ischemia (new ST-T changes, new left bundle branch block, or loss of R-wave voltage),
3. Development of pathological Q-waves in 2 or more contiguous leads in the ECG (or equivalent findings for true posterior MI);
4. Imaging evidence of new loss of viable myocardium or new regional wall motion abnormality;
5. Documentation in the medical record of the diagnosis of acute myocardial infarction based on the cardiac biomarker pattern in the absence of any items enumerated in a-d due to conditions that may mask their appearance (e.g., peri-operative infarct when the patient cannot report ischemic symptoms; baseline left bundle branch block or ventricular pacing)

b. ECG changes associated with prior myocardial infarction can include the following (with or without prior symptoms):

1. Any Q-wave in leads V2-V3 ≥0.02 seconds or QS complex in leads V2 and V3.
2. Q-wave ≥0.03 seconds and ≥0.1 mV deep or QS complex in leads I, II, aVL, aVF, or V4-V6 in any two leads of a contiguous lead grouping (I, aVL, V6; V4-V6; II, III, and aVF).
3. R-wave ≥0.04 seconds in V1-V2 and R/S ≥1 with a concordant positive T-wave in the absence of a conduction defect.
c. Imaging evidence of a region with new loss of viable myocardium at rest in the absence of a non-ischemic cause. This can be manifest as:

1. Echocardiographic, CT, MR, ventriculographic or nuclear imaging evidence of left ventricular thinning or scarring and failure to contract appropriately (i.e., hypokinesis, akinesis, or dyskinesis)

2. Fixed (non-reversible) perfusion defects on nuclear radioisotope imaging (e.g., MIBI, thallium)

d. Medical record documentation of prior myocardial infarction.

Percutaneous Coronary Intervention (PCI): A non-surgical procedure designed to open and maintain the patency of obstructed coronary vessels. This treatment is an invasive procedure performed in the cardiac catheterization lab (e.g., outside of an operating room) by an interventional cardiologist in which a balloon, stent, or other device is delivered to the affected vessel to open and maintain its patency.

Prior CABG Surgery: Indicates the patient had a previous coronary bypass graft prior to the current admission.

Renal Failure–Dialysis: Indicates whether the patient is currently undergoing dialysis.

Risk Factors: Factors that contribute to an individual’s risk of coronary artery disease or of death. These factors are classified as those that can be modified or changed by an individual, and those that cannot be changed. Examples of risk factors that cannot be modified include age, gender, family history of coronary artery disease, and ethnicity. Risk factors that can be controlled include diet, cholesterol levels, obesity, smoking, hypertension, inactive lifestyle, stress, and diabetes.

Standardized Mortality Incidence Rate (SMIR): The ratio of smoothed number of deaths (the number of deaths adjusted for the number of admissions treated at the hospital and the hospital case mix) to expected number of deaths (the expected number of deaths calculated
on the basis of the mortality experience of all cardiac surgery programs) multiplied by the state unadjusted rate. SMIRs are interpreted in terms of their corresponding probability intervals. If the probability interval includes the state rate, then the SMIR is no different from what was expected. If the interval excludes the state rate, then the SMIR is “significantly different” from what was expected. In this case, if the upper limit of the interval is lower than the state rate, then fewer patients than expected died; if the lower limit of the 95% interval is higher than the state rate, then more patients than expected died.

**Status of CABG:** Indicate the clinical status of the patient prior to entering the operating room:

**Elective:** The patient’s cardiac function has been stable in the days or weeks prior to the operation. The procedure could be deferred without increased risk of compromised cardiac outcome.

**Urgent:** Procedure required during same hospitalization in order to minimize chance of further clinical deterioration. Examples include but are not limited to: Worsening, sudden chest pain, congestive heart failure, acute myocardial infarction, anatomy, IABP, unstable angina with intravenous nitroglycerin or rest angina.

**Emergent:** Patients requiring emergency operations will have ongoing, refractory (difficult, complicated, and/or unmanageable) unrelenting cardiac compromise, with or without hemodynamic instability, and not responsive to any form of therapy except cardiac surgery. An emergency operation is one in which there should be no delay in providing operative intervention.

**Emergent Salvage:** The patient is undergoing CPR en route to the operating room or prior to anesthesia induction or has ongoing ECMO to maintain life.
10 Advisory Committees

Mass-DAC gratefully acknowledges the support from the members of the Mass-DAC Committees who have donated their time to improve the database and the quality of cardiac care in the Commonwealth of Massachusetts.

Massachusetts Cardiac Care Hospital Outlier Committee
A Massachusetts Department of Public Health Committee charged with reviewing hospital outlier findings.

Madeleine Biondolillo, M.D.
Associate Commissioner
Director, Bureau of Health Care Safety & Quality
Massachusetts Department of Public Health

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Department of Health Care Policy
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UMass Memorial Medical Center

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Director, Cardiac Catheterization Laboratory
Lahey Hospital & Medical Center

David Torchiana, M.D.
Chairman and Chief Executive Officer
Mass. General Physicians Organization

Continued on next page . . .
Massachusetts Cardiac Care Hospital Outlier Committee

A Massachusetts Department of Public Health Committee charged with reviewing hospital outlier findings.

...Continued from prior page

Thomas Carr, M.D.  Cliff Berger, M.D.
Cardiac Surgeon Interventional Cardiologist
North Shore Medical Center–Salem Hospital Good Samaritan Medical Center

Frederic Resnic, M.D.  Daniel Engelman, M.D.
Chairman Cardiac Surgeon
Department of Cardiovascular Medicine Baystate Medical Center
Lahey Hospital & Medical Center President-Elect of Mass. Chapter of STS

David Shahian, M.D.  Kenneth Rosenfield, M.D.
Research Director Interventional Cardiologist
Center for Quality and Safety Massachusetts General Hospital
Department of Surgery Governor of Mass. Chapter of ACC
Massachusetts General Hospital
Mass-DAC Oversight Committee for Cardiac Surgery

The members of this committee are charged with the task of reviewing blinded summary data for all cardiac surgeons in Massachusetts in the review year. Such data include risk-standardized 30-day all-cause mortality rates (SMIR), surgeon volume, surgeon complication rates, and other STS recommended process measures. For surgeons identified as having statistically significant higher than expected mortality, unblinded case fatality reports are also reviewed. Selection of Committee members is the responsibility of the current President of the Massachusetts chapter of STS.

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sharon-Lise Normand, Ph.D.</td>
<td>Professor of Health Care Policy</td>
<td>Department of Health Care Policy Harvard Medical School</td>
</tr>
<tr>
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</tr>
<tr>
<td>Ralph M. Bolman, III, M.D.</td>
<td>Chief of Cardiac Surgery</td>
<td>Brigham and Women’s Hospital</td>
</tr>
<tr>
<td></td>
<td></td>
<td>President of the Mass. Chapter of STS</td>
</tr>
<tr>
<td>Kenneth Warner, M.D.</td>
<td>Chief of Cardiac Surgery</td>
<td>Tufts Medical Center</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mount Auburn Hospital</td>
</tr>
<tr>
<td>Samuel J. Shubrooks, Jr., M.D.</td>
<td>Interventional Cardiologist</td>
<td>Beth Israel Deaconess Medical Center</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cardiac Surgeon</td>
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<tr>
<td></td>
<td></td>
<td>North Shore Medical Center–Salem Hospital</td>
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<tr>
<td>David Shahian, M.D.</td>
<td>Research Director</td>
<td>Center for Quality and Safety</td>
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<td>Department of Surgery</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Massachusetts General Hospital</td>
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# Mass-DAC Cardiac Surgery Data Adjudication Committee

This committee reviewed patient-specific data elements and corresponding data documentation submitted by hospitals to Mass-DAC in order to determine validity of coding.

<table>
<thead>
<tr>
<th>Name</th>
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<th>Hospital</th>
</tr>
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<tr>
<td>Karl J. Karlson, M.D.</td>
<td>Chief of Cardiac Surgery</td>
<td>Boston Medical Center</td>
</tr>
<tr>
<td>Prem S. Shekar, M.D.</td>
<td>Cardiac Surgeon</td>
<td>Brigham and Women’s Hospital</td>
</tr>
<tr>
<td>Thomas Carr, M.D.</td>
<td>Cardiac Surgeon</td>
<td>North Shore Medical Center–Salem Hospital</td>
</tr>
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<td>Ralph M. Bolman, III, M.D.</td>
<td>Chief of Cardiac Surgery</td>
<td>Brigham and Women’s Hospital</td>
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<tr>
<td>Daniel T. Engelman, M.D.</td>
<td>Cardiac Surgeon</td>
<td>Baystate Medical Center</td>
</tr>
<tr>
<td>Kamal Khabbaz, M.D.</td>
<td>Interim Chief of Cardiac Surgery</td>
<td>Beth Israel Deaconess Medical Center</td>
</tr>
<tr>
<td>Lawrence H. Cohn, M.D.</td>
<td>Cardiac Surgeon</td>
<td>Brigham and Women’s Hospital</td>
</tr>
<tr>
<td>Vladimir Birjiniuk, M.D.</td>
<td>Chief of Cardiac Surgery</td>
<td>Mount Auburn Hospital</td>
</tr>
<tr>
<td>Pauline Philie, R.N.</td>
<td>Data Manager</td>
<td>Cape Cod Hospital</td>
</tr>
<tr>
<td>James Rawn, M.D.</td>
<td>Director, Cardiac Surgery Intensive Care Unit</td>
<td>Brigham and Women’s Hospital</td>
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<tr>
<td>Michelle Doherty, R.N.</td>
<td>Data Manager</td>
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<tr>
<td>James G. Fingleton, M.D.</td>
<td>Chief of Cardiovascular Surgery</td>
<td>Charlton Medical Center</td>
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<tr>
<td>Susan April, R.N.</td>
<td>Data Manager</td>
<td>North Shore Medical Center–Salem Hospital</td>
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<tr>
<td>David Shahian, M.D.</td>
<td>Research Director</td>
<td>Massachusetts General Hospital</td>
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<tr>
<td>Tamar Yehoshua, Perfusionist</td>
<td>Data Manager</td>
<td>Saint Elizabeth’s Medical Center</td>
</tr>
</tbody>
</table>

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February 2014
Publications Committee for Cardiac Surgery

The charge of this committee is to facilitate utilization of shared data from the Massachusetts Cardiac Surgery Data Registry for purposes of reporting observations that are of interest to the medical community and are based on sound scientific principles of study design and analysis. This committee will approve or deny the request before sending the proposal to the Massachusetts Department of Public Health for final approval. The selection of committee members is done by the current president of the Massachusetts STS.

Kamal Khabbaz, M.D.
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Beth Israel Deaconess Medical Center

Ralph M. Bolman, III, M.D.
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Brigham and Women’s Hospital
President of the Mass. Chapter of STS

Frederick Chen, M.D.
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Brigham and Women’s Hospital

Gus Vlahakes, M.D.
Cardiac Surgeon
Massachusetts General Hospital

Joren Madsen, M.D.
Cardiac Surgeon
Massachusetts General Hospital
## Appendix

### Procedure Identification Guidelines for Adult Cardiac Surgery

A comparison of rules used by Mass-DAC, New York State, and the National Society of Thoracic Surgeons for classifying surgeries as *isolated CABG* versus *CABG + other*.

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Mass-DAC</th>
<th>New York State</th>
<th>STS v2.61</th>
<th>STS v2.73</th>
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</thead>
<tbody>
<tr>
<td>Maze: <strong>Open</strong> heart approach</td>
<td>Other</td>
<td>Other</td>
<td>Other</td>
<td>Other</td>
</tr>
<tr>
<td>Maze: <strong>Closed</strong> epicardial approach and radio frequency</td>
<td>CABG</td>
<td>CABG</td>
<td>Other</td>
<td>CABG</td>
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<tr>
<td>Implantable Cardioverter Defibrillator (ICD)</td>
<td>Other</td>
<td>CABG</td>
<td>Other</td>
<td>CABG</td>
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<tr>
<td>Ventricular Lead Insertion for ICD</td>
<td>CABG</td>
<td>CABG</td>
<td>Other</td>
<td>CABG</td>
</tr>
<tr>
<td>Pacemaker Lead Insertions</td>
<td>CABG</td>
<td>CABG</td>
<td>CABG</td>
<td>CABG</td>
</tr>
<tr>
<td>Lung Biopsy</td>
<td>Case Specific</td>
<td>CABG</td>
<td>Other</td>
<td>Other</td>
</tr>
<tr>
<td>Patent Foramen Ovale Closure</td>
<td>CABG</td>
<td>CABG</td>
<td>Other</td>
<td>CABG</td>
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<tr>
<td>Femoral Artery Procedures</td>
<td>CABG</td>
<td>CABG</td>
<td>Other</td>
<td>CABG</td>
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<tr>
<td>Transmyocardial Revascularization</td>
<td>Other</td>
<td>CABG</td>
<td>Other</td>
<td>CABG</td>
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<tr>
<td>Opening of the right atrium for tumor resection</td>
<td>Other</td>
<td>Other</td>
<td>Other</td>
<td>Other</td>
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<tr>
<td>Atrial Appendage</td>
<td>CABG</td>
<td>CABG</td>
<td>CABG</td>
<td>CABG</td>
</tr>
<tr>
<td>Myoxoma</td>
<td>Other</td>
<td>Other</td>
<td>Other</td>
<td>Other</td>
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<tr>
<td>Unplanned Ventricular Assist Device (VAD) Placement</td>
<td>CABG</td>
<td>CABG</td>
<td>Other</td>
<td>CABG</td>
</tr>
<tr>
<td>Planned Ventricular Assist Device (VAD) Placement</td>
<td>Other</td>
<td>Other</td>
<td>Other</td>
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<tr>
<td>Carotid Surgery</td>
<td>Other</td>
<td>CABG</td>
<td>Other</td>
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<tr>
<td>Lead and Device Explants</td>
<td>Other</td>
<td>CABG</td>
<td>Other</td>
<td>Other</td>
</tr>
</tbody>
</table>

\(^a\)No information available regarding how this procedure is categorized by STS.
B Appendix

STS Data Abstraction Tool [8, 7]
Version 2.73

Mass-DAC harvests all optional and not harvested STS variables

This tool is the property of The Society of Thoracic Surgeons and is protected by copyright and other intellectual property laws.
The Society of Thoracic Surgeons
Adult Cardiac Surgery Database
Data Collection Form Version 2.73
January 14, 2011

A. Administrative
Participant ID: Record ID: STS Cost Link: Patient ID:

B. Demographics
Patient Last Name: Patient First Name: Patient Middle Name:
Date of Birth: __ / __ / __ / __ (mm/dd/yyyy) Patient Age: ______ Sex: □ Male □ Female
Social Security Number: __ __ __ - __ __ - __ __ __ __ Medical Record Number:
Patient’s Address:
Street Address: City:
Region: ZIP Code: Country:
Is This Patient’s Permanent Address: □ Yes □ No
(If No) Patient’s Permanent Address:
Street Address: City:
Region: ZIP Code: Country:
Race (Select all that apply:)
□ White: □ Yes □ No □ Black/African American: □ Yes □ No
□ Asian: □ Yes □ No □ Am Indian/Alaskan Nat: □ Yes □ No
□ Native Hawaiian/Pacific Islander: □ Yes □ No □ Other: □ Yes □ No
Hispanic, Latino or Spanish Ethnicity: □ Yes □ No
Referring Cardiologist: Referring Physician:

C. Hospitalization
Hospital Name: ______________________ (If Not Missing) Hospital ZIP Code: Hospital State: Hospital National Provider Identifier: ________________________
Payor - (Select all that apply:)
□ Government Health Insurance: □ Yes □ No (If Yes, select all that apply)
□ Medicare: □ Yes □ No (If Yes —)
□ Medicare Fee For Service: □ Yes □ No
□ Medicaid: □ Yes □ No
□ Military Health Care: □ Yes □ No
□ State-Specific Plan: □ Yes □ No
□ Indian Health Service: □ Yes □ No
□ Correctional Facility: □ Yes □ No
Commercial Health Insurance: □ Yes □ No
Health Maintenance Organization: □ Yes □ No
Non-U.S. Insurance: □ Yes □ No
None / Self: □ Yes □ No
Arrival Date: __ / __ / __ / __ / __ / __ (mm/dd/yyyy) Arrival Time: __ : __ (hh:mm 24-hour clock) Admit Date: __ / __ / __ / __ / __ / __ (mm/dd/yyyy)
Admit Source:
□ Elective Admission
□ Emergency Department
□ Transfer in from another acute care facility (If Transfer —) Other Hospital Performs Cardiac Surgery □ Yes □ No
□ Other
Surgery Date: __ / __ / __ / __ / __ / __ (mm/dd/yyyy)
Discharge Date: __ / __ / __ / __ / __ / __ (mm/dd/yyyy)

D. Risk Factors
Weight (kg): ____________ Height (cm): ____________
Cigarette Smoker: □ Yes □ No (If Yes —) Current Cigarette Smoker: □ Yes □ No
Other Tobacco Use: □ Yes □ No
Family History of Premature Coronary Artery Disease: □ Yes □ No Last Hematocrit: _______ Last WBC Count: _______
Platelet Count Prior to Surgery: _______ International Normalized Ratio prior to Surgery: _______
HIT Antibodies: □ Yes □ No □ Not Applicable Total Bilirubin Prior to Surgery:
Total Albumin Prior to Surgery: _______ A1c Level prior to surgery: _______ Last Creatinine Level Prior to Surgery: _______
Diabetes: □ Yes □ No (If Yes —) Diabetes-Control: □ None □ Diet □ Oral □ Insulin □ Other
### E. Previous Cardiac Interventions

**Previous Cardiac Interventions:**  
(If Yes ↓)  
**Previous CAB prior to current admission:**  
**No**  
**Previous Valve:**  
(If Yes ↓)  
**Previous Aortic Valve Replacement - Surgical:**  
**Yes**  
**No**  
**Previous Aortic Valve Repair - Surgical:**  
**Yes**  
**No**  
**Previous Mitral Valve Replacement - Surgical:**  
**Yes**  
**No**  
**Previous Mitral Valve Repair - Surgical:**  
**Yes**  
**No**  
**Previous Tricuspid Valve Replacement - Surgical:**  
**Yes**  
**No**  
**Previous Tricuspid Valve Repair - Surgical:**  
**Yes**  
**No**  
**Previous Pulmonic Valve Repair / Replacement - Surgical:**  
**Yes**  
**No**  
**Previous Pulmonic Valve Balloon Valvuloplasty:**  
**Yes**  
**No**  
**Previous Mitral Valve Balloon Valvuloplasty:**  
**Yes**  
**No**  
**Previous Transcatheter Valve Replacement:**  
**Yes**  
**No**  
**Previous Percutaneous Valve Repair:**  
**Yes**  
**No**  
**Indication for Reoperation:**  
**Structural Prosthetic Valve Deterioration**  
**Non-structural prosthetic valve dysfunction**  
(If Non-structural prosthetic ↓)  
**Primary type:**  
**Paravalvular Leak**  
**Hemolysis**  
**Entrapment by pannus, tissue, or suture**  
**Sizing or positioning issue**  
**Other**  
**Prosthetic Valve Endocarditis**  
**Valve Thrombosis**  
**Failed Repair**  
**Repeat valve procedure on a different valve**  
**Other**  
**Exact Date of Previous Valve Procedure Known:**  
**Yes**  
**No**  
(If Yes ↓)  
**Date of Previous Valve Procedure:**  
**/ /**  
**Estimate Number of Months Since Previous Valve Procedure:**  
**Previous Other Cardiac:**  
(If Yes ↓)  
**Previous Arrhythmia Surgery:**  
**Yes**  
**No**  
**Previous Congenital:**  
**Yes**  
**No**  
**Previous PCI (Implantable Cardioverter/Defibrillator):**  
**Yes**  
**No**  
**Previous Pacemaker:**  
**Yes**  
**No**  
**Previous PCI (Percutaneous Cardiac Intervention):**  
**Yes**  
**No**  
(If Yes ↓)  
**PCI Performed Within This Episode Of Care:**  
**Yes,**  
**at this facility**  
**Yes,**  
**at some other acute care facility**  
**No**  
(If Yes ↓)  
**Indication for Surgery:**  
**PCI Complication**  
**PCI Failure without Clinical Deterioration**  
**PCI/CABG Hybrid Procedure**  
**PCI Stent:**  
**Yes**  
**No**  
(If Yes ↓)  
**Stent Type:**  
**Bare metal**  
**Drug-eluting**  
**Unknown**  
**PCI Interval:**  
**< 6 Hours**  
**> 6 Hours**  
**Other Previous Cardiovascular Intervention:**  
**Yes**  
**No**

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F. Preoperative Cardiac Status

Prior Myocardial Infarction: □ Yes □ No (If Yes ↓)
MI When: □ <=6 Hrs □ >6 Hrs but <24 Hrs □ 1 to 7 Days □ 8 to 21 Days □ >21 Days

Anginal Classification Within 2 weeks: □ No Symptoms, No Angina □ CCA I □ CCA II □ CCA III □ CCA IV
Heart Failure Within 2 weeks: □ Yes □ No (If Yes→) Classification-NYHA: □ Class I □ Class II □ Class III □ Class IV

Prior Heart failure: □ Yes □ No

Cardiac Presentation on Admission: □ No Symptoms, No Angina □ Symptoms Unlikely to be Ischemia □ Stable Angina □ Unstable Angina □ Non-ST Elevation MI (Non-STEMI) □ ST Elevation MI (STEMI)

Cardiogenic Shock: □ Yes □ No

Resuscitation: □ Yes □ No

Arrhythmia When: □ None □ Remote □ Recent (If Recent ↓)
Arrhythmia Type: □ Vtach/Vfib: □ Yes □ No □ Sinus Sinus Syndrome: □ Yes □ No □ Afib/Aflutter: □ Yes □ No

Type: □ Paroxysmal □ Continuous/Persistent

Mean Gradient: ________ mmHg

Highest Mean Gradient: ________ mmHg

Aortic Valve Disease: □ Yes □ No (If Yes ↓)
Aortic Etiology: □ Degenerative (senile)
□ Endocarditis (If Endocarditis→) Root Abscess: □ Yes □ No □ Congenital (If Congenital→) Type: □ Bicuspid □ Other □ Rheumatic

□ Primary Aortic Disease: (If PAD→) Type: □ Marfans □ Other Connective tissue disorder □ Atherosclerotic Aneurysm □ Inflammatory □ Aortic Dissection □ Idiopathic Root Dilation

□ LV Outflow Tract Obstruction: (If LV outflow tract obstruction) Type: □ HOCM □ Sub-aortic membrane □ Sub-aortic Tunnel

□ Supravalvular Aortic Stenosis □ Tumor: (If Tumor→) Type: □ Myxoma □ Papillary fibroelastoma □ Carcinoid □ Other □ Trauma □ Other

Aortic Stenosis: □ Yes □ No (If Yes ↓)
Smallest Aortic Valve Area: ________ cm²
Highest Mean Gradient: ________ mmHg

Aortic Insufficiency: □ None □ Trace/Trivial □ Mild □ Moderate □ Severe

G. Preoperative Medications

Beta Blockers: □ Yes □ No □ Contraindicated
ACE or ARB Inhibitors Within 48 Hours: □ Yes □ No
Nitrates-I.V.: □ Yes □ No

Anticoagulants: □ Yes □ No (If Yes→) Medication Name: □ Heparin (Unfractionated) □ Heparin (Low Molecular)
□ Thrombin Inhibitors □ Other

Preoperative Antiarrhythmics: □ Yes □ No
Coumadin: □ Yes □ No

Inotropes: □ Yes □ No
Steroids: □ Yes □ No
Aspirin: □ Yes □ No

Lipid Lowering: □ Yes □ No (If Yes→) Medication Type: □ Statin □ Non-statin □ Both
ADP Inhibitors Within Five Days: □ Yes □ No (If Yes→) ADP Inhibitors Discontinuation: _______ (# days prior to surgery)
Antplatelets Within 5 Days: □ Yes □ No
Glycoprotein IIb/IIIa Inhibitor: □ Yes □ No (If Yes→) Medication Name: □ Abciximab (ReoPro) □ Eptifibatide (Integrilin)
□ Tirofiban (Aggrastat)

Thrombolytics within 48 hours: □ Yes □ No

H. Hemodynamics/Cath/Echo

Cardiac Catheterization Performed: □ Yes □ No (If Yes→) Cardiac Catheterization Date: __ __/ __ __/ __ __ __ __
Number Diseased Vessels: □ None □ One □ Two □ Three
Left Main Disease >= 50%: □ Yes □ No
Proximal LAD >= 70%: □ Yes □ No

Ejection Fraction Done: □ Yes □ No (If Yes ↓)
Ejection Fraction: _______ (%) Ejection Fraction Method: □ LV Gram □ Radionuclide □ Estimate □ ECHO □ MRI/CT □ Other

LV Systolic Dimension: ________ (mm) LV End-Diastolic Dimension: ________ (mm)
PA Systolic Pressure Measured: □ Yes □ No (If Yes→) PA Systolic Pressure: ________ mmHg (highest prior to surgery)
<table>
<thead>
<tr>
<th>Mitral Valve Disease:</th>
<th>☐ Yes ☐ No (If Yes ↓)</th>
</tr>
</thead>
</table>
| Mitral Etiology:     | ☐ Annular or Degenerative Disease (If Annular or Degenerative Disease ↓)
|                      | ☐ Endocarditis  
|                      | ☐ Rheumatic  
|                      | ☐ Ischemic (If Ischemic→)  
|                      | ☐ Annular or Degenerative Disease (If Annular or Degenerative Disease ↓)
|                      | ☐ Chronic  
|                      | ☐ Congenital  
|                      | ☐ Hypertrophic Obstructive Cardiomyopathy (HOCM)  
|                      | ☐ Tumor: (If Tumor→) ☐ Myxoma  
|                      | ☐ Papillary fibroelastoma  
|                      | ☐ Carcinoid  
|                      | ☐ Other  
|                      | ☐ Other  
| Mitral Valve Disease Functional Class: | ☐ Type I  
|                      | ☐ Type II  
|                      | ☐ Type IIIa  
|                      | ☐ Type IIIb  
| Mitral Stenosis:     | ☐ Yes ☐ No (If Yes ↓)  
|                      | Smallest Mitral Valve Area : ________ cm²  
|                      | Highest Mean Gradient: _________ mm Hg  
| Mitral Insufficiency: | ☐ None  
|                      | ☐ Trace/trivial  
|                      | ☐ Mild  
|                      | ☐ Moderate  
|                      | ☐ Severe  

<table>
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<tr>
<th>Tricuspid Valve Disease:</th>
<th>☐ Yes ☐ No (If Yes ↓)</th>
</tr>
</thead>
</table>
| Tricuspid Etiology:     | ☐ Functional  
|                        | ☐ Endocarditis  
|                        | ☐ Congenital  
|                        | ☐ Tumor  
|                        | ☐ Trauma  
|                        | ☐ Other  
| Tricuspid Stenosis:     | ☐ Yes ☐ No  
| Tricuspid Insufficiency: | ☐ None  
|                        | ☐ Trace/trivial  
|                        | ☐ Mild  
|                        | ☐ Moderate  
|                        | ☐ Severe  

<table>
<thead>
<tr>
<th>Pulmonic Valve Disease:</th>
<th>☐ Yes ☐ No (If Yes ↓)</th>
</tr>
</thead>
</table>
| Pulmonic Stenosis:      | ☐ Yes ☐ No  
| Pulmonic Insufficiency: | ☐ None  
|                        | ☐ Trace/trivial  
|                        | ☐ Mild  
|                        | ☐ Moderate  
|                        | ☐ Severe  

### I. Operative

#### Surgeon:

- **Surgeon Identification Number:**

#### Taxpayer Identification Number:

#### Incidence:
- ☐ First cardiovascular surgery  
- ☐ First re-op cardiovascular surgery  
- ☐ Second re-op cardiovascular surgery  
- ☐ Third re-op cardiovascular surgery  
- ☐ Fourth or more re-op cardiovascular surgery  

#### Status:
- ☐ Elective  
- ☐ Urgent (If Urgent↓  
  - ☐ AMI  
  - ☐ IABP  
  - ☐ Worsening CP  
  - ☐ CHF  
  - ☐ Anatomy  
  - ☐ USA  
  - ☐ Rest Angina  
  - ☐ Valve Dysfunction  
  - ☐ Aortic Dissection  
  - ☐ Angiographic Accident  
  - ☐ Cardiac Trauma  
  - ☐ Infected Device  
  - ☐ Syncope  
  - ☐ PCI/CABG Hybrid  
  - ☐ PCI Failure w/out clinical deterioration  
- ☐ Emergent (If Emergent↓  
  - ☐ Shock Circ Support  
  - ☐ Shock No Circ Support  
  - ☐ Pulmonary Edema  
  - ☐ AEMI  
  - ☐ Ongoing Ischemia  
  - ☐ Valve Dysfunction  
  - ☐ Aortic Dissection  
  - ☐ Angiographic Accident  
  - ☐ Cardiac Trauma  
  - ☐ Infected Device  
  - ☐ Syncope  
  - ☐ PCI/CABG Hybrid  
  - ☐ Anatomy  
- ☐ Emergent Salvage  

#### Was case previously attempted during this admission, but canceled:
- ☐ Yes ☐ No (If Yes→  
  - Date of previous case: __ __/__ __/__ __ __ __ (mm/dd/yyyy)  
  - Timing of previous case: ☐ Prior to induction of anesthesia  
  - ☐ After induction, prior to incision  
  - ☐ After incision made  
  - ☐ Anesthesiology event  
  - ☐ Cardiac arrest  
  - ☐ Equipment/supply issue  
  - ☐ Unanticipated tumor  
  - ☐ Other  

#### Planned previous procedure:
- CABG  
  - ☐ Yes ☐ No  
- Valve  
  - ☐ Yes ☐ No  
- Mechanical Assist Device  
  - ☐ Yes ☐ No  
- Other Cardiac  
  - ☐ Yes ☐ No  
- Other Non-cardiac  
  - ☐ Yes ☐ No
Was the current procedure canceled:  □ Yes  □ No
(If Yes→) Canceled Timing:  □ Prior to induction of anesthesia  □ After induction, prior to incision  □ After incision made
Canceled Reason:  □ Anesthesiology event  □ Cardiac arrest  □ Equipment/supply issue  □ Unanticipated tumor  □ Other
Planned procedure:  □ CABG  □ Other Cardiac  □ Other Non-cardiac  □ Mechanical Assist Device  □ Yes  □ No
Coronary Artery Bypass:  □ Yes  □ No  (If "Yes" complete Section J)
Explant Device:  _______  (Refer to Explant Device Key below)

Valve Prosthesis Explant:  □ Yes  □ No  (If Yes ↓)
Explant Position:  □ Aortic  □ Mitral  □ Tricuspid  □ Pulmonic
Explant Type:  □ Unknown  □ Anuloplasty Device  □ Hemorrhoidectomy  □ Transcatheter Device
Device:  □ None (Homograft or Pulmonary Autograft)  □ Cryolife  □ Edwards  □ Lillehei-Kaster  □ OmniScience
Manufacturer:  □ ATS  □ Baxter  □ Biocore  □ Björk-Shiley  □ CarboMedics  □ Carpenter-Edwards  □ Cosgrove-Edwards  □ Cryolife O'Brien  □ MCRI  □ Medtronic  □ Sorin-Puig
□ Geneseel  □ Hancock  □ Ionescu-Shiley  □ Laborcor  □ LifeNet  □ OmniCarbon  □ Other
□ Medtronic Colvin Galloway  □ Medtronic-Duran  □ Medtronic-Hall  □ Starr-Edwards  □ Ultracor
□ Medtronic  □ St. Jude Medical  □ St. Jude Tailor  □ Transcatheter Device

Valve Surgery:  □ Yes  □ No  (If Yes ↓)  (If "Yes" complete Section K)
Valve Prosthesis Explant:  □ Yes  □ No  (If Yes ↓)
Explant Device Key

Explant Device:  _______  (Refer to Explant Device Key below)

Second Valve Prosthesis Explant:  □ Yes  □ No  (If Yes ↓)
Explant Position:  □ Aortic  □ Mitral  □ Tricuspid  □ Pulmonic
Explant Type:  □ Unknown  □ Anuloplasty Device  □ Hemorrhoidectomy  □ Transcatheter Device
Device:  □ None (Homograft or Pulmonary Autograft)  □ Cryolife  □ Edwards  □ Lillehei-Kaster  □ OmniScience
Manufacturer:  □ ATS  □ Baxter  □ Biocore  □ Björk-Shiley  □ CarboMedics  □ Carpenter-Edwards  □ Cosgrove-Edwards  □ Cryolife O'Brien  □ MCRI  □ Medtronic  □ Sorin-Puig
□ Geneseel  □ Hancock  □ Ionescu-Shiley  □ Laborcor  □ LifeNet  □ OmniCarbon  □ Other
□ Medtronic Colvin Galloway  □ Medtronic-Duran  □ Medtronic-Hall  □ Starr-Edwards  □ Ultracor
□ Medtronic  □ St. Jude Medical  □ St. Jude Tailor  □ Transcatheter Device

Explant Device Key

2 = ATS Mechanical Prosthesis  66 = Medtronic ADVANTAGE Mechanical Prosthesis
3 = Björk-Shiley Convex-Concave Mechanical Prosthesis  9 = OmniCarbon Mechanical Prosthesis
4 = Björk-Shiley Monostrut Mechanical Prosthesis  54 = OmniScience Mechanical Prosthesis
6 = CarboMedics Mechanical Prosthesis  11 = Sorin Bicarbon (Baxter Mira) Mechanical Prosthesis
57 = CarboMedics Carbo-Seal Ascending Aortic Valved Conduit Prosthesis  12 = Sorin Monoleaflet Aicarbon Mechanical Prosthesis
58 = CarboMedics Carbo-Seal Valsalva Ascending Aortic Valved Conduit Prosthesis  13 = St. Jude Medical Mechanical Heart Valve
59 = CarboMedics Reduced Cuff Aortic Valve  67 = St. Jude Medical Masters Series Mechanical Heart Valve
60 = CarboMedics Standard Aortic Valve  68 = St. Jude Medical Masters Series Aortic Valve Graft Prosthesis
61 = CarboMedics Top-Hat Supra-annular Aortic Valve  69 = St. Jude Medical Mechanical Heart Valve Hemodynamic Plus (HP)
62 = CarboMedics OptiForm Mitral Valve  70 = St. Jude Medical Masters Series Hemodynamic Plus Valve with FlexCuff
63 = CarboMedics Standard Mitral Valve  Sewing Ring
64 = CarboMedics Orbis Universal Valve  71 = St. Jude Medical Regent Valve
65 = CarboMedics Small Adult Aortic and Mitral Valves  14 = Starr-Edwards Caged-Ball Prosthesis
66 = Medtronic-Hall/Hall Easy-Fit Mechanical Prosthesis  15 = Ultracor Mechanical Prosthesis
67 = Medtronic-Hall Conduit
<table>
<thead>
<tr>
<th>Bioprosthesis</th>
<th>Homograft</th>
<th>Autograft</th>
<th>Ring - Annuloplasty</th>
<th>Band - Annuloplasty</th>
<th>Other</th>
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</thead>
<tbody>
<tr>
<td>100 = ATS 3f Aortic Bioprosthesis</td>
<td>85 = Medtronic Contegra Bovine Jugular Bioprosthesis</td>
<td>45 = Pulmonary Autograft to aortic root (Ross Procedure)</td>
<td>52 = St. Jude Medical Séguin Annuloplasty Ring</td>
<td>106 = ATS Stimulus Flex-C Band</td>
<td>77 = Other</td>
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<tr>
<td>72 = Edwards Prima Stentless Porcine Bioprosthesis - Subcoronary</td>
<td>37 = Mitroflow Pericardial Bioprosthesis</td>
<td>94 = CarboMedics Mosaic Porcine Bioprosthesis</td>
<td>106 = ATS Medtronic Flex-O Ring</td>
<td>128 = Myxo Eltlogix Annuloplasty Ring</td>
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<td>19 = Biocor Porcine Bioprosthesis</td>
<td>40 = St. Jude Medical-Biocomplant Porcine Bioprosthesis</td>
<td>96 = CarboMedics Mosaic Porcine Bioprosthesis - Subcoronary</td>
<td>123 = ATS Stimulus Flexible Annuloplasty Ring</td>
<td>137 = Medtronic Colvin Galloway Future Ring</td>
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<tr>
<td>74 = Biocor Stentless Porcine Bioprosthesis - Subcoronary</td>
<td>86 = St. Jude Medical Biocor Stented Tissue Valve</td>
<td>124 = ATS Medtronic Colvin Galloway Future Ring</td>
<td>124 = ATS Medtronic Colvin Galloway Future Ring</td>
<td>138 = Carmedic Edwards Physio II</td>
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<tr>
<td>75 = Biocor Stentless Porcine Bioprosthesis - Root</td>
<td>87 = St. Jude Medical Epic Stented Porcine Bioprosthesis</td>
<td>125 = ATS Medtronic Colvin Galloway Future Ring</td>
<td>127 = Cosgrove-Edwards Annuloplasty System with Duraflo Treatment</td>
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<tr>
<td>21 = CarboMedics PhotoFix Pericardial Bioprosthesis</td>
<td>88 = St. Jude Medical Toronto Root Stentless Porcine Bioprosthesis</td>
<td>125 = ATS Medtronic Colvin Galloway Future Ring</td>
<td>128 = Myxo Eltlogix Annuloplasty Ring</td>
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<td>76 = Carpentier-Edwards Porcine Bioprosthesis</td>
<td>38 = Sorin Pericarbon Stentless Pericardial Bioprosthesis</td>
<td>126 = Carpentier-Edwards Classic Annuloplasty Ring with Duraflo Treatment</td>
<td>131 = Sorin Meso 3D Ring</td>
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<tr>
<td>78 = Edwards Prima Plus Stentless Porcine Bioprosthesis - Root</td>
<td>112 = Carpentier-Edwards PERIMOUNT Theon Pericardial Bioprosthesis</td>
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<td>22 = Carpentier-Edwards PERIMUMNT Pericardial Bioprosthesis</td>
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<td>80 = CryoLife O'Bien Stentless Porcine Bioprosthesis - Root</td>
<td>120 = Carpentier-Edwards PERIMOUNT Theon Pericardial Bioprosthesis with Tricentrix Holder.</td>
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<td>138 = Carmedic Edwards Physio II</td>
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<td>55 = Hancock Standard Porcine Bioprosthesis</td>
<td>121 = St. Jude Medical Biocor Supra Stented Porcine Bioprosthesis</td>
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<tr>
<td>28 = Hancock II Porcine Bioprosthesis</td>
<td>122 = St. Jude Medical Epic Supra Stented Porcine Bioprosthesis.</td>
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<td>29 = Hancock Modified Orifice Porcine Bioprosthesis</td>
<td>134 = Carpentier Edwards Physio II</td>
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<td>138 = Carmedic Edwards Physio II</td>
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<td>30 = Ionescu-Shiley Pericardial Bioprosthesis</td>
<td>118 = Carpentier-Edwards Duraflex Low Pressure Porcine Bioprosthesis</td>
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<td>31 = Laborc Stented Porcine Bioprosthesis</td>
<td>119 = Carpentier-Edwards Duraflex Low Pressure ESR Porcine Bioprosthesis</td>
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<td>81 = Laborc Stentless Porcine Bioprosthesis - Subcoronary</td>
<td>123 = ATS Medtronic Simulus Semi-Rigid Annuloplasty Ring</td>
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<td>82 = Laborc Stentless Porcine Bioprosthesis - Root</td>
<td>125 = ATS Medtronic Classic Annuloplasty Ring with Duraflo Treatment</td>
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<td>83 = Medtronic Freestyle Stentless Porcine Bioprosthesis - Subcoronary</td>
<td>126 = Carpentier-Edwards Physio Annuloplasty Ring with Duraflo Treatment</td>
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<tr>
<td>84 = Medtronic Freestyle Stentless Porcine Bioprosthesis - Root</td>
<td>127 = Cosgrove-Edwards Annuloplasty System with Duraflo Treatment</td>
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<td>138 = Carmedic Edwards Physio II</td>
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<tr>
<td>86 = Medtronic Intact Porcine Bioprosthesis</td>
<td>128 = Myxo Eltlogix Annuloplasty Ring</td>
<td></td>
<td>138 = Carmedic Edwards Physio II</td>
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</tr>
<tr>
<td>35 = Medtronic Mosaic Porcine Bioprosthesis</td>
<td>131 = Sorin Meso 3D Ring</td>
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<td>138 = Carmedic Edwards Physio II</td>
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<td></td>
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<tr>
<td>90 = CryoLife Pulmonary Homograft</td>
<td>132 = UNIRING, Universal Annuloplasty System</td>
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<td>138 = Carmedic Edwards Physio II</td>
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</tr>
<tr>
<td>91 = CryoLife CryoValve SG(Decellularized)Aortic Homograft</td>
<td>137 = Medtronic Colvin Galloway Future Ring</td>
<td></td>
<td>138 = Carmedic Edwards Physio II</td>
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</tr>
<tr>
<td>92 = CryoLife CryoValve SG Pulmonary Homograft</td>
<td>50 = Medtronic-Duran Ancore Ring</td>
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<td>138 = Carmedic Edwards Physio II</td>
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<td>41 = Homograft Aortic - Subcoronary</td>
<td>51 = Sorin-Puig-Messana Ring</td>
<td></td>
<td>138 = Carmedic Edwards Physio II</td>
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</tr>
</tbody>
</table>

## VAD Implanted or Removed

- [ ] No
- [ ] Yes, implanted
- [ ] Yes, explanted
- [ ] Yes, implanted and explanted

## Other Cardiac Procedure

- [ ] Yes
- [ ] No

## Other Non-Cardiac Procedure

- [ ] Yes
- [ ] No

## Unplanned Procedure

- [ ] No

- (If Yes)
  - Unplanned CABG:
    - [ ] Yes
    - [ ] No
  - Unplanned Aortic Valve Procedure:
    - [ ] Yes
    - [ ] No
  - Unplanned Mitral Valve Procedure:
    - [ ] Yes
    - [ ] No
  - Unplanned Aorta Procedure:
    - [ ] Yes
    - [ ] No
  - Unplanned VAD Insertion:
    - [ ] Yes
    - [ ] No
  - Unplanned Other Procedure:
    - [ ] Yes
    - [ ] No

Enter up to 10 CPT-1 Codes pertaining to the surgery for which the data collection form was initiated:

1. 
2. 
3. 
4. 
5. 
6. 
7. 
8. 
9. 
10. 

## OR Entry Date And Time

- [ ] Yes
- [ ] No

## OR Exit Date And Time

- [ ] Yes
- [ ] No

## Initial Intubation Date and Time

- [ ] Yes
- [ ] No

## Initial Extubation Date and Time

- [ ] Yes
- [ ] No

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<table>
<thead>
<tr>
<th><strong>Appropriate Antibiotic Selection:</strong></th>
<th><strong>Appropriate Antibiotic Administration Timing:</strong></th>
<th><strong>Appropriate Antibiotic Discontinuation:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ Yes ☐ No ☐ Exclusion</td>
<td>☐ Yes ☐ No ☐ Exclusion</td>
<td>☐ Yes ☐ No ☐ Exclusion</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>CPB Utilization:</strong></th>
<th>☐ None</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ Combination (If Combination)</td>
<td></td>
</tr>
<tr>
<td>Combination Plan:</td>
<td>☐ Planned</td>
</tr>
<tr>
<td>☐ Unplanned (If Unplanned)</td>
<td></td>
</tr>
<tr>
<td>Reason:</td>
<td></td>
</tr>
<tr>
<td>☐ Exposure/visualization</td>
<td></td>
</tr>
<tr>
<td>☐ Bleeding</td>
<td></td>
</tr>
<tr>
<td>☐ Inadequate size and/or diffuse disease of distal vessel</td>
<td></td>
</tr>
<tr>
<td>☐ Hemodynamic instability (hypotension/arrhythmias)</td>
<td></td>
</tr>
<tr>
<td>☐ Conduit quality and/or trauma</td>
<td></td>
</tr>
<tr>
<td>☐ Other</td>
<td></td>
</tr>
<tr>
<td>☐ Full</td>
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</tbody>
</table>

| **Cardiopulmonary Bypass Time (minutes):** | __________ |
| **Cardiopulmonary Bypass Time (minutes):** | __________ |
| **Cardiopulmonary Bypass Time (minutes):** | __________ |

<table>
<thead>
<tr>
<th><strong>Arterial Cannulation Site:</strong></th>
<th>(Select all that apply)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aortic</td>
<td>☐ Yes ☐ No</td>
</tr>
<tr>
<td>Femoral</td>
<td>☐ Yes ☐ No</td>
</tr>
<tr>
<td>Other</td>
<td>☐ Yes ☐ No</td>
</tr>
<tr>
<td>Axillary</td>
<td>☐ Yes ☐ No</td>
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</table>

<table>
<thead>
<tr>
<th><strong>Venous Cannulation Site:</strong></th>
<th>(Select all that apply)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Femoral</td>
<td>☐ Yes ☐ No</td>
</tr>
<tr>
<td>Jugular</td>
<td>☐ Yes ☐ No</td>
</tr>
<tr>
<td>Right Atrial</td>
<td>☐ Yes ☐ No</td>
</tr>
<tr>
<td>Left Atrial</td>
<td>☐ Yes ☐ No</td>
</tr>
<tr>
<td>Pulmonary Vein</td>
<td>☐ Yes ☐ No</td>
</tr>
<tr>
<td>Caval/Bicaval</td>
<td>☐ Yes ☐ No</td>
</tr>
<tr>
<td>Other</td>
<td>☐ Yes ☐ No</td>
</tr>
</tbody>
</table>

| **Circulatory Arrest:** | ☐ Yes ☐ No (If Yes) |
| Circulatory Arrest Without Cerebral Perfusion Time: | __________ (min) |
| Circulatory Arrest With Cerebral Perfusion: | ☐ Yes ☐ No |
| (If Yes) Cerebral Perfusion Time: | __________ (min) |
| Cerebral Perfusion Type: | ☐ Antegrade ☐ Retrograde ☐ Both antegrade and retrograde |

| **Cerebral Oximetry Used:** | ☐ Yes ☐ No (If Yes) |
| Pre-Induction Baseline Regional Oxygen Saturation: | Left: ____ (%) Right: ____ (%) |
| Cumulative Saturation Below Threshold: | Left: ____ (min -%) Right: ____ (min -%) |
| Cerebral Oximeter Provided First Indication: | ☐ Yes ☐ No |
| Skin Closure Regional Oxygen Saturation: | Left: ____ (%) Right: ____ (%) |

| **Concentric Calcification:** | ☐ Yes ☐ No |
| Echo Assessment of Ascending Aorta/Arch: | ☐ Yes ☐ No (If Yes) |
| Assessment of Aorta Disease: | ☐ Normal Aorta ☐ Extensive intimal thickening |
| ☐ Protruding Atheroma < 5 mm ☐ Protruding Atheroma >= 5 mm |
| ☐ Mobile plaques ☐ Not documented |

| **Assessment Altered Plan:** | ☐ Yes ☐ No |

| **Intraop Blood Products Used:** | ☐ Yes ☐ No |
| Intraop Blood Products Refused: | ☐ Yes ☐ No |
| (If Not) | |
| (If Yes) | Red Blood Cell Units: | | |
| Fresh Frozen Plasma Units: | | |
| Cryoprecipitate Units: | | |
| Platelet Units: | | |
| Factor VIII: | | |

| **Intraop Antifibrinolytic Medications:** | Epsilon Amino-Caproic Acid: ☐ Yes ☐ No |
| Tranexamic Acid: ☐ Yes ☐ No |

<p>| <strong>Intraoperative TEE Performed post procedure:</strong> | ☐ Yes ☐ No (If Yes) |
| Highest level aortic insufficiency found: | ☐ None ☐ Trace/trivial ☐ Mild ☐ Moderate ☐ Severe |
| Highest level mitral insufficiency found: | ☐ None ☐ Trace/trivial ☐ Mild ☐ Moderate ☐ Severe |
| Highest level tricuspid insufficiency found: | ☐ None ☐ Trace/trivial ☐ Mild ☐ Moderate ☐ Severe |</p>
<table>
<thead>
<tr>
<th>J. Coronary Bypass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hybrid Procedure CAB and PCI Performed: Yes □ No □ (If Yes ↓)</td>
</tr>
<tr>
<td>Status: □ Planned - concurrent □ Planned - staged □ Unplanned</td>
</tr>
<tr>
<td>PCI Procedure Performed: □ Angioplasty □ Stent</td>
</tr>
</tbody>
</table>

| Number of Distal Anastomoses with Arterial Conduits: ________ |

| Number of Distal Anastomoses with Venous Conduits: ________ (If >0 ↓) |
| Vein Harvest Technique: □ Endoscopic □ Direct Vision (open) □ Both □ Cryopreserved |
| Saphenous Vein Harvest Time: ________ (minutes) |
| Saphenous Vein Preparation Time: ________ (minutes) |

| Internal Mammary Artery used for Grafts: □ Left IMA □ Right IMA □ Both IMAs □ No IMA |
| (If No IMA →) Indicate Primary Reason: □ The IMA is not a suitable conduit due to size or flow □ Subclavian stenosis □ Previous cardiac or thoracic surgery □ Previous mediastinal radiation □ Emergent or salvage procedure □ No LAD disease |
| (If Left, Right or Both IMAs →) Total # of Distal Anastomoses done using IMA grafts: ________ |
| IMA Harvest Technique: □ Direct Vision (open) □ Thoracoscopy □ Combination □ Robotic Assist |

| Number of Radial Arteries Used for Grafts: ________ (If >0 ↓) |
| Number of Radial Artery Distal Anastomoses: ________ |
| Radial Distal Anastomoses Harvest Technique: □ Endoscopic □ Direct Vision (open) □ Both |
| Radial Artery Harvest Time: ________ (minutes) |
| Radial Artery Preparation Time: ________ (minutes) |

| Number Other Arterial Distal Anastomoses Used (other than radial or IMA): ________ |
### Native Coronary Disease Location Key:

<table>
<thead>
<tr>
<th>Number</th>
<th>Location</th>
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</thead>
<tbody>
<tr>
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<td>Left Main</td>
</tr>
<tr>
<td>2</td>
<td>Prox LAD</td>
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<td>3</td>
<td>Mid LAD</td>
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<td>Distal LAD</td>
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<td>Diagonal 1</td>
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<tr>
<td>6</td>
<td>Diagonal 2</td>
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<tr>
<td>7</td>
<td>Circumflex</td>
</tr>
<tr>
<td>8</td>
<td>OM 1</td>
</tr>
<tr>
<td>9</td>
<td>OM 2</td>
</tr>
<tr>
<td>10</td>
<td>OM 3</td>
</tr>
<tr>
<td>11</td>
<td>RCA</td>
</tr>
<tr>
<td>12</td>
<td>PDA</td>
</tr>
<tr>
<td>13</td>
<td>PLB</td>
</tr>
<tr>
<td>14</td>
<td>AM branches</td>
</tr>
<tr>
<td>15</td>
<td>Ramus</td>
</tr>
</tbody>
</table>

For each question, check the one choice that applies for each graft:

<table>
<thead>
<tr>
<th>CABG NUMBER</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRAFT DONE</td>
<td>Yes</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

### Native Coronary Disease Location (See key above)

#### Highest Percent Stenosis in Native Vessel

<table>
<thead>
<tr>
<th>Previous Conduit</th>
<th>Yes - Diseased</th>
<th>Yes - No disease</th>
<th>No previous conduit</th>
</tr>
</thead>
</table>

#### Proximal Site

<table>
<thead>
<tr>
<th>In Situ Mammary</th>
<th>Ascending aorta</th>
<th>Descending aorta</th>
<th>Subclavian artery</th>
<th>Innominate artery</th>
<th>T-graft off SVG</th>
<th>T-graft off Radial</th>
<th>T-graft off LIMA</th>
<th>T-graft off RIMA</th>
</tr>
</thead>
</table>

#### Proximal Technique

<table>
<thead>
<tr>
<th>Running</th>
<th>Interrupted</th>
<th>Anastomotic Device</th>
<th>Anastomotic Assist Device</th>
</tr>
</thead>
</table>

#### Conduit

<table>
<thead>
<tr>
<th>Vein graft</th>
<th>In Situ LIMA</th>
<th>In Situ RIMA</th>
<th>Free IMA</th>
<th>Radial artery</th>
<th>Other arteries, homograft</th>
</tr>
</thead>
</table>

#### Distal Insertion Site

<table>
<thead>
<tr>
<th>Right Coronary (RCA)</th>
<th>Acute Marginal (AM)</th>
<th>Posterior Descending Artery (PDA)</th>
<th>Posterolateral Branch (PLB)</th>
<th>Proximal LAD</th>
<th>Mid LAD</th>
<th>Distal LAD</th>
<th>Diagonal 1</th>
<th>Diagonal 2</th>
<th>Ramus</th>
<th>Obtuse Marginal 1</th>
<th>Obtuse Marginal 2</th>
<th>Obtuse Marginal 3</th>
<th>Other</th>
</tr>
</thead>
</table>

#### Distal Technique

<table>
<thead>
<tr>
<th>Running</th>
<th>Interrupted</th>
<th>Clips</th>
<th>Anastomotic device</th>
</tr>
</thead>
</table>

#### Distal Position

<table>
<thead>
<tr>
<th>End to Side</th>
<th>Sequential (side to side)</th>
</tr>
</thead>
</table>

#### Endarterectomy

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

#### Hybrid

<table>
<thead>
<tr>
<th>No</th>
<th>Angioplasty</th>
<th>Stent</th>
</tr>
</thead>
</table>

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# K. Valve Surgery

<table>
<thead>
<tr>
<th>Valve Surgery</th>
<th>(If Valve Surgery=Yes ↓)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aortic Valve Procedure Performed:</td>
<td>Yes</td>
</tr>
<tr>
<td>Procedure Performed:</td>
<td></td>
</tr>
<tr>
<td>□ Replacement</td>
<td></td>
</tr>
<tr>
<td>□ Repair / Reconstruction</td>
<td></td>
</tr>
<tr>
<td>Primary Repair Type: (Select all that apply)</td>
<td></td>
</tr>
<tr>
<td>Commissural Annuloplasty:</td>
<td>Yes</td>
</tr>
<tr>
<td>Leaflet plication:</td>
<td>Yes</td>
</tr>
<tr>
<td>Leaflet free edge reinforcement (PTFE):</td>
<td>Yes</td>
</tr>
<tr>
<td>Leaflet commissural resuspension suture:</td>
<td>Yes</td>
</tr>
<tr>
<td>Division of fused leaflet raphe:</td>
<td>Yes</td>
</tr>
<tr>
<td>Root Reconstruction with valved conduit:</td>
<td></td>
</tr>
<tr>
<td>Replacement and insertion aortic non-valved conduit:</td>
<td></td>
</tr>
<tr>
<td>Resuspension AV without replacement of ascending aorta:</td>
<td></td>
</tr>
<tr>
<td>Resuspension AV with replacement of ascending aorta:</td>
<td></td>
</tr>
<tr>
<td>Apico-aortic conduit (Aortic valve bypass):</td>
<td></td>
</tr>
<tr>
<td>Autograft with pulmonary valve-Ross procedure:</td>
<td></td>
</tr>
<tr>
<td>Homograft:</td>
<td></td>
</tr>
<tr>
<td>Valve sparing root reimplantation (David):</td>
<td></td>
</tr>
<tr>
<td>Valve sparing root remodeling (Yacoub):</td>
<td></td>
</tr>
<tr>
<td>Transcatheter Valve Replacement:</td>
<td>Yes</td>
</tr>
<tr>
<td>Transapical</td>
<td></td>
</tr>
<tr>
<td>Transaxillary</td>
<td></td>
</tr>
<tr>
<td>Transfemoral</td>
<td></td>
</tr>
<tr>
<td>Aortic Annular Enlargement:</td>
<td>Yes</td>
</tr>
<tr>
<td>Resection of sub-aortic stenosis:</td>
<td>Yes</td>
</tr>
<tr>
<td>Implant Model Number:____________________ Size:  ___________</td>
<td></td>
</tr>
</tbody>
</table>

| Mitral Valve Procedure Performed: | Yes | No |
| Procedure Performed: | | |
| □ Repair | | |
| (If Repair→ Repair Type: (Select all that apply):) | | |
| Annuloplasty: | Yes | No | |
| Leaflet Resection: | Yes | No | |
| Sliding Plasty: | Yes | No | |
| Annular decalcification: | Yes | No | |
| Neochords (PTFE): | Yes | No | |
| Chordal /Leaflet transfer: | Yes | No | |
| Leaflet extension/replacement/patch: | Yes | No | |
| Edge to Edge Repair: | Yes | No | |
| Mitral commissurotomy: | Yes | No | |
| □ Replacement | | |
| (If Replacement→ Repair attempted prior to Mitral Valve Replacement: Yes | No | |
| Implant Model Number:____________________ Size:  ___________ |
| Mitral Chords Preserved: | None | Anterior | Posterior | Both |

| Tricuspid Valve Procedure Performed: | Yes | No |
| □ Annuloplasty only | | |
| □ Replacement | | |
| □ Reconstruction with Annuloplasty | | |
| □ Reconstruction without Annuloplasty | | |
| □ Valvectomy | | |
| Implant Model Number:____________________ Size:  ___________ |

| Pulmonic Valve Procedure Performed: | Yes | No |
| □ Replacement | | |
| □ Reconstruction | | |
| □ Valvectomy | | |
| Implant Model Number:____________________ Size:  ___________ |
### L. Mechanical Cardiac Assist Devices

#### Intra Aortic Balloon Pump (IABP)

- **Yes**  
- **No** (If Yes)

**IABP Insertion:**  
- **Preop**  
- **Intraop**  
- **Postop**

**Primary Reason for Insertion:**  
- Hemodynamic instability  
- PTCA Support  
- Unstable Angina  
- CPB Weaning Failure  
- Prophylactic

**Date IAPB Removed:** __/__/___ (mm/dd/yyyy)

#### Catheter Based Assist Device Used:

- **Yes**  
- **No** (If Yes)

**Device:**  
- Impella  
- Tandem Heart  
- Other

**When Inserted:**  
- **Preop**  
- **Intraop**  
- **Postop**

**Primary Reason for Insertion:**  
- Hemodynamic instability  
- CPB weaning failure  
- PCI failure  
- Other

**Date Device Removed:** __/__/___ (mm/dd/yyyy)

#### Extracorporeal Membrane Oxygenation (ECMO)

- **Yes**  
- **No** (If Yes)

**ECMO Initiated:**  
- **Preop**  
- **Intraop**  
- **Postop**  
- Non-operative

**Clinical Indication for ECMO Placement:**  
- Cardiac Failure  
- Respiratory Failure  
- Hypothermia  
- Rescue/salvage

#### Previous VAD

- **Yes**  
- **No** (If Yes)

**Implanted at another facility:**  
- **Yes**  
- **No**

**Prev VAD Insertion Date:** __/__/___ (mm/dd/yyyy)

**Prev VAD Indication:**  
- Bridge to Transplantation  
- Bridge to Recovery  
- Destination  
- Post Cardiomyotomy Ventricular failure  
- Device Malfunction  
- End of Life

**Prev VAD Transplant Date**
- **Yes**  
- **No**

**Prev VAD Device:**  
- RVAD  
- LVAD  
- BiVAD  
- TAH

**Prev VAD Implant Reason:**
- **Yes**  
- **No**

(Refer to current “On-Demand Device Lists” document)

---

**References to “Initial VAD” refer to the initial VAD for this hospitalization, not a VAD placed during a previous hospitalization.**

**VAD Implant Type:**
- Right VAD (RVAD)  
- Left VAD (LVAD)  
- Biventricular VAD (BiVAD)  
- Total Artificial Heart (TAH)

**VAD Device:**
- (Refer to current “On-Demand Device Lists” document)

**Explant Reason:**
- Cardiac Transplant  
- Recovery  
- Device Transfer  
- Device-Related Infection  
- Device Malfunction  
- End of Life

**Indication for this VAD:**
- Bridge to Transplantation  
- Bridge to Recovery  
- Destination  
- Postcardiomyotomy Ventricular Failure  
- Device Malfunction  
- End of Life

**Initial Implant Data**

<table>
<thead>
<tr>
<th>Implant Type</th>
<th>VAD Device</th>
<th>Implant Date</th>
<th>Explant</th>
<th>Explant Date</th>
<th>Explant Reason</th>
<th>Transplant Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>____________</td>
<td>__________</td>
<td><strong>/</strong>/______</td>
<td><strong>/</strong>/______</td>
<td><strong>/</strong>/_____</td>
<td><strong>/</strong>/_____</td>
<td><strong>/</strong>/_____</td>
</tr>
</tbody>
</table>

**Additional Implant(s) Data**

**Second Device Implanted:**  
- **Yes**  
- **No** (If Yes)

<table>
<thead>
<tr>
<th>Implant Type#2</th>
<th>VAD Device#2</th>
<th>Implant Date#2</th>
<th>Explant#2</th>
<th>Explant Date#2</th>
<th>Explant Reason#2</th>
<th>Transplant Date#2</th>
</tr>
</thead>
<tbody>
<tr>
<td>____________</td>
<td>____________</td>
<td><strong>/</strong>/______</td>
<td><strong>/</strong>/______</td>
<td><strong>/</strong>/_____</td>
<td><strong>/</strong>/_____</td>
<td><strong>/</strong>/_____</td>
</tr>
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</table>

**Third Device Implanted:**  
- **Yes**  
- **No** (If Yes)

<table>
<thead>
<tr>
<th>Implant Type#3</th>
<th>VAD Device#3</th>
<th>Implant Date#3</th>
<th>Explant#3</th>
<th>Explant Date#3</th>
<th>Explant Reason#3</th>
<th>Transplant Date#3</th>
</tr>
</thead>
<tbody>
<tr>
<td>____________</td>
<td>____________</td>
<td><strong>/</strong>/______</td>
<td><strong>/</strong>/______</td>
<td><strong>/</strong>/_____</td>
<td><strong>/</strong>/_____</td>
<td><strong>/</strong>/_____</td>
</tr>
</tbody>
</table>

**Primary VAD Complications Data:**

- Intracranial Bleed  
- Embolic Stroke  
- Driveline and/or cannula Infection  
- Pump Pocket Infection  
- Endocarditis  
- Device Malfunction  
- Hemolysis  
- Bowel Obstruction

**Additional Complications** (not specific to initial VAD as above) to be collected in Postoperative Events section.

**VAD Discharge Status:**
- With VAD  
- Without VAD  
- Expired in Hospital
M. Other Cardiac Procedure

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Yes</th>
<th>No</th>
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</thead>
<tbody>
<tr>
<td>Left Ventricular Aneurysm Repair</td>
<td></td>
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<tr>
<td>Ventricular Septal Defect Repair</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atrial Septal Defect Repair</td>
<td></td>
<td></td>
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<tr>
<td>Surgical Ventricular Restoration</td>
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<tr>
<td>Congenital Defect Repair</td>
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<tr>
<td>Transmyocardial Laser Re-vascularization (TMR)</td>
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<tr>
<td>Cardiac Trauma</td>
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<td></td>
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<tr>
<td>Cardiac Transplant</td>
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<tr>
<td>Arrhythmia Correction Surgery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrhythmia Correction Surgery Lead Extraction</td>
<td></td>
<td></td>
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<tr>
<td>Atrial Fibrillation Surgical Procedure</td>
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<td></td>
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<tr>
<td>Arrhythmia Correction Surgery Lead Insertion or Replacement</td>
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<td></td>
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<tr>
<td>Arrhythmia Correction Surgery Lead Extraction</td>
<td></td>
<td></td>
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<td>Aortic Procedure Type</td>
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<td></td>
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<tr>
<td>Aneurysm</td>
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<td></td>
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<td>Dissection</td>
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<tr>
<td>Endovascular Procedure (TEVAR)</td>
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<td></td>
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<tr>
<td>Tumor Resection</td>
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<tr>
<td>Pulmonary Thromboembolectomy</td>
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</tbody>
</table>

N. Other Non Cardiac Procedures

<table>
<thead>
<tr>
<th>Procedure</th>
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<th>No</th>
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</thead>
<tbody>
<tr>
<td>Carotid Endarterectomy</td>
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<tr>
<td>Other Vascular</td>
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<td></td>
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<tr>
<td>Other Thoracic</td>
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</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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O. Post Operative
Postoperative Creatinine Level: __________
Blood Products Used Postoperatively: □ Yes □ No (If Yes →)
Red Blood Cell Units: ________ Fresh Frozen Plasma Units: ________ Cryoprecipitate Units: ________ Platelet Units: ________

Exeutubated in OR: □ Yes □ No
Re-intubated During Hospital Stay: □ Yes □ No (If Yes →) Additional Hours Ventilated: ____________
ICU Visit: □ Yes □ No (If Yes →) Initial ICU Hours: ____________
Readmission to ICU: □ Yes □ No (If Yes →) Additional ICU Hours: ____________
Post Op Echo Performed: □ Yes □ No (If Yes →)
  Highest level aortic insufficiency found: □ None □ Trace/trivial □ Mild □ Moderate □ Severe
  Highest level mitral insufficiency found: □ None □ Trace/trivial □ Mild □ Moderate □ Severe
  Highest level tricuspid insufficiency found: □ None □ Trace/trivial □ Mild □ Moderate □ Severe
Post Op Ejection Fraction Done: □ Yes □ No (If Yes →)
Post Op Ejection Fraction (%)

Cardiac Enzymes (biomarkers) Drawn: □ Yes □ No (If Yes →) Peak CKMB: ________ Peak Troponin I ________ Peak Troponin T ________
12-Lead EKG Findings: □ Not performed □ No significant changes □ New Pathological Q-wave or LBBB

Imaging Study Findings:
  □ Not performed
  □ Angiographic evidence of new thrombosis or occlusion of graft or native coronary
  □ Imaging evidence of new loss of viable myocardium
  □ No evidence of new myocardial injury

P. Postoperative Events
In Hospital Postoperative Event Occurred: □ Yes □ No (If Yes →)
  Operative
  ReOp for Bleeding/Tamponade: □ Yes □ No (If Yes →) Bleed Timing: □ Acute □ Late
  ReOp for Valvular Dysfunction: □ Yes □ No
  ReOp for Graft Occlusion: □ Yes □ No
  ReOp for Other Cardiac Reasons: □ Yes □ No
  ReOp for Other Non-Cardiac Reasons: □ Yes □ No
  Open chest with planned delayed sternal closure: □ Yes □ No
  Sternotomy Issue: □ Yes □ No (If Yes →) Sternal instability/dehiscence (sterile): □ Yes □ No

  Infection (see CDC definitions in training manual)
  Surgical Site Infection: □ Yes □ No (If Yes →)
    Sternal Superficial Wound Infection: □ Yes □ No
    Deep Sternal Infection: □ Yes □ No
    Mediastinitis: □ Yes □ No (If Yes →)
      Diagnosis Date: ________/______/______ (dd/mm/yyyy)
      Secondary Procedure Open with Packing/Irrigation: □ Yes □ No
      Secondary Procedure Wound Vac: □ Yes □ No
      Secondary Procedure Muscle Flap: □ Yes □ No
      Secondary Procedure Omental Flap: □ Yes □ No
    Thoracotomy: □ Yes □ No
    Conduit Harvest or Cannulation Site: □ Yes □ No
    Wound Intervention - Open with Packing/Irrigation: □ Yes □ No
    Wound Intervention - Wound Vac: □ Yes □ No
    Sepsis: □ Yes □ No (If Yes →) Positive Blood Cultures: □ Yes □ No

  Neurologic
  Postoperative Stroke (Perm>24 hours): □ Yes □ No
  Transient Ischemic Attack (TIA): □ Yes □ No
  Encephalopathy: □ None □ Anoxic □ Embolic □ Drug □ Metabolic □ Intracranial Bleeding □ Other
  Paralysis: □ Yes □ No (If Yes →) Paralysis Type: □ Transient □ Permanent

  Pulmonary
  Prolonged Ventilation: □ Yes □ No
  Pneumonia: □ Yes □ No
  Venous Thromboembolism - VTE: □ Yes □ No (If Yes →)
  Pulmonary Thromboembolism: □ Yes □ No
  Deep Venous Thrombosis: □ Yes □ No
  Pleural Effusion Requiring Drainage: □ Yes □ No

  Renal
  Renal Failure: □ Yes □ No (If Yes →)
    Dialysis (Newly Required): □ Yes □ No (If Yes →) Required after Hospital Discharge: □ Yes □ No
    Ultra Filtration Required: □ Yes □ No

  Vascular
  Iliac/Femoral Dissection: □ Yes □ No
  Acute Limb Ischemia: □ Yes □ No
**Other**

- Rhythm Disturbance Requiring Permanent Device: [ ] Pacemaker  [ ] ICD  [ ] Pacemaker/ICD  [ ] None
- Cardiac Arrest: [ ] Yes  [ ] No
- Anticoagulant Event: [ ] Yes  [ ] No
- Tamponade (Non-Surgical Intervention): [ ] Yes  [ ] No
- Gastro-Intestinal Event: [ ] Yes  [ ] No
- Atrial Fibrillation: [ ] Yes  [ ] No
- Aortic Dissection: [ ] Yes  [ ] No
- Recurrent Laryngeal Nerve Injury: [ ] Yes  [ ] No
- Phrenic Nerve Injury: [ ] Yes  [ ] No
- Other: [ ] Yes  [ ] No

**Q. Mortality**

<table>
<thead>
<tr>
<th>Mortality:</th>
<th>[ ] Yes  [ ] No</th>
<th>Discharge Status:</th>
<th>[ ] Alive  [ ] Dead</th>
<th>Status at 30 days After Surgery:</th>
<th>[ ] Alive  [ ] Dead  [ ] Unknown</th>
</tr>
</thead>
</table>

Primary method used to verify 30-day status:
- [ ] Phone call to patient or family
- [ ] Evidence of life in medical record
- [ ] Social Security Death Master File
- [ ] Letter from medical provider
- [ ] Office visit to surgeon >= 30 days after procedure
- [ ] Other

Operative Death: [ ] Yes  [ ] No
Mortality - Date __/__/__ (mm/dd/yyyy)
Location of Death:
- [ ] OR During Initial Surgery
- [ ] Hospital (Other than OR)
- [ ] Home
- [ ] Other
- [ ] Extended Care Facility
- [ ] Acute Rehabilitation
- [ ] OR During Reoperation
- [ ] Unknown
- [ ] Other

Primary Cause of Death (select only one):
- [ ] Cardiac
- [ ] Neurologic
- [ ] Renal
- [ ] Vascular
- [ ] Infection
- [ ] Pulmonary
- [ ] Valvular
- [ ] Unknown
- [ ] Other

**R. Discharge**

<table>
<thead>
<tr>
<th>ADP Inhibitors:</th>
<th>[ ] Yes  [ ] No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antiarrhythmics:</td>
<td>[ ] Yes  [ ] No</td>
</tr>
<tr>
<td>Aspirin:</td>
<td>[ ] Yes  [ ] No  [ ] Contraindicated</td>
</tr>
<tr>
<td>ACE or ARB Inhibitors:</td>
<td>[ ] Yes  [ ] No, contraindicated  [ ] No, not indicated</td>
</tr>
<tr>
<td>Beta Blockers:</td>
<td>[ ] Yes  [ ] No  [ ] Contraindicated</td>
</tr>
<tr>
<td>Lipid Lowering:</td>
<td>[ ] Yes  [ ] No  [ ] Contraindicated (If Yes →)</td>
</tr>
<tr>
<td>Coumadin:</td>
<td>[ ] Yes  [ ] No</td>
</tr>
<tr>
<td>Direct Thrombin Inhibitors:</td>
<td>[ ] Yes  [ ] No</td>
</tr>
</tbody>
</table>

Discharge Location:
- [ ] Home
- [ ] Extended Care/Transitional Care Unit/Rehab
- [ ] Other Hospital
- [ ] Nursing Home
- [ ] Hospice
- [ ] Other

Cardiac Rehabilitation Referral: [ ] Yes  [ ] No  [ ] Not Applicable
Smoking Cessation Counseling: [ ] Yes  [ ] No  [ ] Not Applicable

**S. Readmission**

<table>
<thead>
<tr>
<th>Readmit &lt;=30 Days from Date of Procedure:</th>
<th>[ ] Yes  [ ] No (If Yes ↓)</th>
</tr>
</thead>
</table>

Readmit Primary Reason:
- [ ] Anticoagulation Complication - Valvular
- [ ] Anticoagulation Complication - Pharmacological
- [ ] Arrhythmia/Heart Block
- [ ] Congestive Heart Failure
- [ ] Myocardial Infarction and/or Recurrent Angina
- [ ] Pericardial Effusion and/or Tamponade
- [ ] Pneumonia or other Respiratory Complication
- [ ] Coronary Artery Dysfunction
- [ ] Valve Dysfunction
- [ ] Infection - Deep Sternal / Mediastinitis
- [ ] Infection - Conduit Harvest Site
- [ ] Renal Failure
- [ ] TIA
- [ ] Permanent CVA
- [ ] Acute Vascular Complication
- [ ] Subacute Endocarditis
- [ ] VAD Complication
- [ ] Transplant Rejection
- [ ] PE
- [ ] DVT
- [ ] Other - Related Readmission
- [ ] Other - Nonrelated Readmission

Readmit Primary Procedure:
- [ ] OR for Bleeding
- [ ] Pacemaker Insertion / AICD
- [ ] PCI
- [ ] Pericardiectomy / Pericardiocentesis
- [ ] OR for Coronary Arteries
- [ ] OR for Valve
- [ ] OR for Sternal Debridement / Muscle Flap
- [ ] Dialysis
- [ ] OR for Vascular
- [ ] No Procedure Performed
- [ ] Other Procedure
- [ ] Unknown
Bibliography


