TECHNICAL REPORT ON ADULT CORONARY ARTERY BYPASS GRAFT SURGERY IN THE COMMONWEALTH OF MASSACHUSETTS

January 1 – December 31, 2002

Mass-DAC

Department of Health Care Policy

Harvard Medical School

October 2004

FUNDED BY THE MASSACHUSETTS DEPARTMENT OF PUBLIC HEALTH

MASSACHUSETTS DATA ANALYSIS CENTER (MASS-DAC)

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MASSACHUSETTS CARDIAC SURGERY CENTERS 2002

Baystate Medical Center 759 Chestnut Street Springfield, MA 01199	Massachusetts General Hospital 12 Fruit Street Boston, MA 02114
Beth Israel Deaconess Medical Center 330 Brookline Avenue Boston, MA 02115	Mount Auburn Hospital 330 Mount Auburn Street Cambridge, MA 02138
Boston Medical Center 88 East Newton Street Boston, MA 02118	North Shore Medical Center - Salem Hospital 81 Highland Avenue Salem, MA 01970 (Did not perform Cardiac Surgery until 2003)
Brigham & Women's Hospital 75 Francis Street Boston, MA 02115	Caritas St. Elizabeth's Medical Center 736 Cambridge Street Boston, MA 02315
Cape Cod Hospital 27 Park Street Hyannis, MA 02537	St. Vincent Hospital at Worcester Medical Center 20 Worcester Center Blvd. Worcester, MA 01608
Southcoast Hospital Group – Charlton Memorial Hospital 363 Highland Avenue Fall River, MA 02720	Tufts-New England Medical Center 750 Washington Street Boston, MA 02111
Lahey Clinic 41 Mall Road Burlington, MA 01805	UMass Memorial Medical Center 55 Lake Avenue North Worcester, MA 01655

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INTRODUCTION

What is in this Report?

This report describes technical procedures for calculating hospital-specific mortality rates thirty days following coronary artery bypass graft (**CABG**) surgery performed between January 1, 2002 and December 31, 2002 in Massachusetts hospitals. Surgeries performed in United States Government 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 their surgery.

Not all hospitals in the Commonwealth are permitted to perform cardiac surgery and hospitals wishing to have a new cardiac surgery program must submit an application to the Determination of Need Program in the Massachusetts Department of Public Health. In 2002, there were eleven established cardiac surgery programs in Massachusetts and three newly-approved community cardiac surgery programs. Southcoast Hospital Group – Charlton Memorial Hospital performed their first cardiac surgery on April 18, 2002; Cape Cod Hospital followed on August 15, 2002; and while North Shore Medical Center – Salem Hospital was approved for a cardiac surgery program, this hospital did not perform their first cardiac surgery until 2003.

This document reports hospital-specific standardized mortality incidences rates following CABG surgeries for the thirteen cardiac surgery programs in the Commonwealth that performed at least one CABG surgery between January 1, 2002 and December 31, 2002. Patients undergoing CABG at the same time as valve surgery are not used to determine the hospital mortality incidence rates.

What is Coronary Artery Bypass Graft 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 a build-up of plaque. Plaque may build up because of high cholesterol, high blood pressure, smoking, diabetes, genetic predisposition, or other factors. If the plaque build-up 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, this 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) depending on the degree of blockage, patient symptoms and the number of coronary arteries involved. Coronary artery bypass graft (CABG) surgery is a type of cardiac surgery that creates a new route 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 is the only major heart surgery performed are referred to as ***Isolated CABG*** procedures.

Definition of Study Population

The patient population consists of all patients aged 18 years or older undergoing isolated coronary bypass graft surgery in Massachusetts adult acute care hospitals between January 1, 2002 and December 31, 2002. If multiple cardiac surgeries occur during an admission, admissions are categorized by the primary (initial) surgery. Isolated CABG included 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 was 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 procedures were classified as "Other Cardiac Surgery". Lung biopsies performed in conjunction with a CABG were considered on a case by case basis (see Appendix 1). **Table 1** lists the distribution of the 7,661 admissions in which at least one cardiac surgery was performed in Massachusetts hospitals during 2002.

Table 1: Surgical Procedure Type Classification of Adult Cardiac Surgery Admissions in MA Hospitals, 2002. *Includes one patient lost to follow up who was excluded from the CABG analysis.

Surgical Procedure Type	No. of Cardiac Surgery Admissions	% of Cardiac Surgery Admissions
Isolated CABG	4604*	60
Mitral Valve Replacement (MVR)	160	2
Aortic Valve Replacement (AVR)	518	7
MVR + CABG	81	1
AVR + CABG	606	8
AVR + MVR	37	0.5
Other Cardiac Surgery	1545	20
Non-Cardiac (Thoracic) Procedures	110	1
All Cardiac Surgeries	**7661***	**100**

Why Report on CABG Surgery?

CABG surgeries account for the majority of cardiac surgeries performed nationally and are costly. In 2002, isolated CABG surgeries accounted for sixty percent of the more than 7,600 cardiac surgery hospital admissions in the Commonwealth.

What is Mass-DAC?

Mass-DAC is a data-coordinating center responsible to the Massachusetts Department of Public Health for the collection, storage, and analyses of the cardiac data submitted by Massachusetts hospitals. Mass-DAC is located in the Department of Health Care Policy, Harvard Medical School in Boston (www.massdac.org). Mass-DAC is advised by several committees on an on-going basis: the Massachusetts Cardiac Care Quality Advisory Commission, the Cardiac Advisory Board, and the Cardiac Surgery Data Adjudication Committee. In addition, both the National Society of Thoracic Surgeons and the Massachusetts Society of Thoracic Surgeons serve as resources.

SUMMARY OF DATA COLLECTION & VERIFICATION PROCEDURES

Definition of Patient Outcome

Mortality, regardless of cause, measured within 30 days from 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.

Massachusetts Cardiac Surgery Programs

Thirteen cardiac surgery centers treated patients in the Commonwealth in calendar year 2002. Two of the thirteen centers were new: Southcoast Hospital Group – Charlton Memorial Hospital and Cape Cod Hospital. The first cardiac surgery at Charlton Memorial Hospital occurred on April 18, 2002, while the first surgery at Cape Cod Hospital occurred on August 15, 2002.

Data Sources

Three different data sources were used: patient-specific data collected by hospital personnel using the Society of Thoracic Surgeons (STS) National Cardiac Surgery Database software; hospital administrative discharge data; and vital statistics information provided by the Massachusetts Department of Public Health.

Mass-DAC STS Data. Patient-specific risk factor and outcome data were collected by hospital personnel using the STS National Cardiac Surgery Database software. Two different software versions (see Appendices 2 & 3) were used to abstract data: generally, version 2.35, containing 189 variables, was used for surgeries occurring between January 1, 2002 and June 30, 2002, and version 2.41, containing 217 variables, for surgeries subsequent to June 30, 2002. The main differences between the versions were the addition of discharge medications, and tracking of intensive care unit and ventilation hours in 2.41. Although other programs had participated in the STS registry in the past, only the UMass Memorial Medical Center and Lahey Clinic were actively participating immediately prior to initiation of the state regulations.

Massachusetts Inpatient Acute Hospital Case Mix and Charge Database. Hospital discharge data for the period October 1, 2001 through September 30, 2003 (fiscal years 2002 and 2003) were obtained from the Massachusetts Division of Health Care Finance and Policy. Data elements included: hospital identifier; gender, race, age and home zip code of the patient; ICD-9 and CPT codes; discharge status; dates of admission and discharge; date of surgery; and patient medical record number. Social security numbers were removed from this database.

Massachusetts Mortality Index Database. Date of death information obtained from Massachusetts death certificates was available for all deaths occurring in Massachusetts between January 1, 2002 and December 31, 2002 from the Massachusetts Registry of Vital Records and Statistics. While the primary source of 30-day mortality rates was the hospital-reported rates, the mortality index database was used in a verification procedure. 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 by the above mentioned variables, and supplied Mass-DAC with the date of death for all applicable patients.

Mass-DAC Data Collection Procedures

The majority of Massachusetts hospitals used clinical staff, such as physicians, nurses, and perfusionists, to collect information. Data were either entered directly into the STS software database by the clinical staff or by a data manager, or 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 transmitted by hospitals and harvested by Mass-DAC regularly (**Table 2**). This process involved submitting protected data during specific harvest periods. Data were encrypted, password protected, stored on a disk, and sent by Federal Express or registered mail. Data were also transmitted electronically using secure messaging software (PGP software). Hospitals were allotted up to four weeks to submit data during the harvest periods. For example, because 30-day mortality information for patients undergoing cardiac surgery in Quarter 4 (between October 1, 2002 and December 31, 2002) would be complete by January 31, 2003, the harvest began March 1, 2003, one month after the last 30-day follow-up. Data harvests were scheduled quarterly for collection of 3 months of data. To catch up with the data collection that began on January 1, 2002, one 2002 harvest collected 6 months of data rather than the usual 3 months. Hospitals were permitted to submit corrected data as often as desired and could sign-off on its accuracy and completeness at any time. However, all data were required to be complete by September 1, 2003, after which no changes were accepted without written permission from Mass-DAC.

Table 2. Cardiac Surgery Data Harvest Schedule for Surgeries Performed in 2002. §Because Mass-DAC was formed in May 2002, the first data harvest did not occur until the fall of 2002.

Month of Data Harvest	Dates of Cardiac Surgery
September 1, 2002§	January 1, 2002 – March 31, 2002 (Quarter 1)
December 1, 2002§	April 1, 2002 – September 30, 2002 (Quarters 2&3)
March 1, 2003	October 1, 2002 – December 31, 2002 (Quarter 4)
September 1, 2003 (2002 Data Close-Out)	January 1, 2002 – December 31, 2002 (Year 2002)

Cleaning and Validation Procedures

Hospital data submissions were cleaned and verified using a variety of procedures: continuous feedback via on-going data quality reports, meetings and communication, and review of concordance with administrative datasets and with medical chart audits.

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 elements and identifying cases with missing, out-of-usual range, or inconsistent data. The hospitals were given thirty days to correct the data deficiencies identified by Mass-DAC following receipt of each Quality Report.

There were a total of 114 Quality Reports returned to the hospitals for the three 2002 data harvests with a mean of 8.8 reports per hospital (range of 5 to 12). With each data harvest, fewer Quality Reports were returned as data managers and data collectors became more comfortable with the data collection and submission process.

MA Administrative Datasets. Thirty-day mortality was verified by linking the hospital report of mortality to the Registry of Vital Records and Statistics information. While the Registry data records only deaths in Massachusetts, it does provide an additional mechanism to ascertain outcomes. The mortality index database was linked to the Mass-DAC STS database by the patient's last name, date of birth, and social security number. Mass-DAC found high agreement between the hospital mortality reports and the Vital Records. There were 6 patients reported as 30-day survivors by the hospitals who were reported as 30-day deaths in the Vital Records. Of these 6, Mass-DAC confirmed that 5 were dead within 30 days and determined that 1 patient reported as a 30-day mortality by a hospital was alive. Lastly, one patient was lost to follow-up for mortality despite repeated attempts by both the hospital and Mass-DAC to obtain the information. This patient was removed from the analysis file, leaving **4603** patients for review. The Massachusetts Inpatient Case Mix Dataset was used to determine whether all appropriate cases of cardiac surgery from each institution were submitted to Mass-DAC.

Meetings and Communication. Mass-DAC communicated regularly via electronic mail and telephone with the data managers to clarify definitional or procedural issues, and to serve as a facilitator to the national STS. Recently asked and answered questions were posted on a public website (www.massdac.org) and were discussed at Data Manager meetings. Meetings with the data managers, Chiefs of Cardiac Surgery, and the Cardiac Advisory Board were scheduled to share preliminary results. This process helped identify areas where data may be inconsistent, incorrectly coded, or outlying (**Table 3**).

Table 3. Meetings with Cardiac Surgery Data Managers, Chiefs of Cardiac Surgery, and Advisory Committees.

Date	Attendees and Purpose of Meeting
August 15, 2002	Data Managers. Discussed STS data submission procedures.
November 6, 2003	Joint meeting with Data Managers and MA STS. Discussed coding of angina variables.
January 9, 2003	MA Cardiac Care Quality Advisory Commission. Discussed preliminary results of data collection and proposed audit procedures.
January 16, 2003	Chiefs of Cardiac Surgery. Presented preliminary results of cardiac surgery data for the period January 1, 2002 – March 31, 2002.
March 20, 2003	Mass-DAC Cardiac Advisory Board Committee. Presented results of cardiac surgery data for surgeries for the period January 1, 2002 – March 31, 2002.
September 18, 2003	Data Managers. Reviewed data submission procedures, Quality Reports and definition issues.
December 17, 2003	Data Managers. Discussed definitions, coding, changes in harvest schedule, STS new version changes, and data security.
January 7, 2004	Chiefs of Cardiac Surgery. Presented preliminary results of cardiac surgery data for the period January 1, 2002 – December 31, 2002.
February 11, 2004	Data Managers. Presented preliminary results of cardiac surgery data for the period January 1, 2002 – December 31, 2002.
May/June/July2004	Cardiac Surgery Adjudication Committee meetings – audit of medical chart records for coding verification.
July 21, 2004	Data Managers. Discussed definitions, version changes and process.
September 8, 2004	Cardiac Advisory Board. Presented 2002 isolated CABG surgery results for the period January 1, 2002 – December 31, 2002.
October 7, 2004	Chiefs of Cardiac Surgery - Presented 2002 isolated CABG results for the period January 1, 2002 – December 31, 2002.
October 13, 2004	Data Managers – Presented 2002 isolated CABG results for the period January 1, 2002 – December 31, 2002.

Audit Data. Two separate audits were undertaken. First, in the Spring of 2003, MassPRO, a healthcare quality improvement organization, was contracted to conduct chart audits of a stratified random sample of cardiac surgery patients at each cardiac surgery program. A computerized chart-review instrument was developed that defined a range of patient-specific risk factors associated with quality of care. Using Mass-DAC STS information for the first 9 months of 2002, medical record audits were undertaken for all patients reported dead at 30-days in addition to a random sample of all 30-day survivors who had cardiac surgery within each hospital. MassPRO nurses were trained by Mass-DAC staff in the use of the electronic audit instrument. Approximately 50 charts per cardiac surgery program were reviewed to determine data consistency and accuracy.

Early examination of the chart information with the electronic data did not indicate major problems. Because these audits occurred prior to the data close-out, a second audit was implemented in May 2004.

After review and discussion of the 2002 cardiac surgery data with the Cardiac Advisory Committee and the Chiefs of Cardiac Surgery, Mass-DAC requested medical record verification from each institution for a selection of abstracted items specific to the institution's data submission. Operative reports/discharge summaries were requested for all procedures that were coded as "Other Cardiac Surgery" (see Table 1) that were not clearly specified. Additional examples of records that were requested included discharge summaries and operative reports to verify surgery type; admission, history, discharge summaries, pulmonary function tests to verify severity of chronic lung disease; and catheterization reports for additional verification of the number of diseased vessels or status of the surgery. Institutions were required to provide Mass-DAC verification data by March 31, 2004. Hospitals that had an incorrectly coded variable for most patients were permitted to recode that variable and to submit a random sample of the recoded records for verification. The Mass-DAC Cardiac Surgery Data Adjudication Committee then reviewed every requested medical record. Coding that the Committee agreed with remained unchanged. Coding that any member of the Committee disagreed with was reviewed by the entire Committee and discussed until a consensus was met. If the coding was changed by the Committee, it was also changed in the Mass-DAC database and the hospital was notified.

Out of a total of 1,820 charts that were identified for audit, 724 charts were randomly selected and reviewed by the Adjudication Committee. A total of 835 changes were made by the Committee. These changes included 535 records from one institution which were recoded for the angina variable. During the chart audit process, the Adjudication Committee established the guidelines for which procedures would be included as isolated CABG surgery (Appendix 1).

UNIVARIATE AND BIVARIATE DISTRIBUTION OF RISK FACTORS AND 30-DAY MORTALITY OVERALL & STRATIFIED BY HOSPITAL

Who Receives CABG Surgery in Massachusetts?

Table 4 lists the age-sex-race distribution for 4603 adult CABG surgery patients at 13 cardiac surgery programs in the Commonwealth. The unadjusted 30-day all-cause mortality rate is 2.19% (n = 101 died within 30 days of surgery). Patients who resided out of state at the time of their surgery comprised 9% of the 4603 CABG admissions.

Table 4: Age-Sex-Race Distribution for all Adult Isolated CABG Surgery Admissions in MA Hospitals during January 1, 2002 – December 31, 2002. Entries represent numbers of patients.

Age Group	Females					Males				
	White	African American	Hispanic	Other	Total	White	African American	Hispanic	Other	Total
18 – 44	17	1	3	0	21	81	4	6	9	100
45 – 54	67	8	4	3	82	397	10	16	20	443
55 – 64	213	7	12	10	242	881	13	37	40	971
65 – 74	363	16	11	19	409	1095	14	23	47	1179
≥ 75	391	6	7	16	420	706	1	11	18	736
Total	1051	38	37	48	**1174**	3160	42	93	134	**3429**

Relationship Between Risk Factors and 30-Day Mortality

Table 5 lists the mean values of the risk factors and their relationship with mortality. The risk factors were selected based on a literature review and represent the complete set available in the STS database. In the table, the **Mean** represents the percent (for categorical variables) of Isolated CABG patients reported to have the characteristic or the sample average (for continuous-valued variables). **Relationship with 30-Day Mortality** represents the association of each risk factor with mortality. For categorical variables, this is defined as the fraction that died within 30-days of surgery.

Consider race which is a categorical variable. Ninety-one and one-half percent of all isolated CABG patients treated in the Commonwealth are white; 2.28% of white patients died within 30-days following Isolated CABG surgery. For continuous-valued variables, the relationship with 30-day mortality represents the mean covariate value for those who died minus the mean covariate value for those who survived. For example,

the average age was 66.5 years, and patients who died within 30-days were 5.93 years older than those who survived 30-days.

Table 5. Relationship Between 30-Day Mortality and Risk Factors Following Adult Isolated CABG Surgery in the Commonwealth of Massachusetts, 2002. Based on 4603 surgeries and 101 deaths (2.19**%**). §For categorical variables, the fraction who died within 30-days of surgery; for continuous-valued variables, the mean covariate value for those who died minus the mean covariate value for those who survived.

Variable	Mean	Relationship with 30-Day Mortality§
Mean age, years	66.5	5.93
Race, %		
White	91.5	2.28
Black	1.7	1.25
Hispanic	2.8	1.54
Asian	1.0	0.00
Other	2.9	1.49
Sex, %		
Male	74.5	1.78
Female	25.5	3.41
[1]Mean Body Surface Area, m^2	2.02	-0.09
Diabetes Mellitus, %		
Present	38.0	2.52
Absent	62.0	2.00
Chronic Lung Disease, %		
None	88.8	2.03
Mild	6.7	3.27
Moderate	3.2	3.38
Severe	1.4	4.76
Hypertension, %		
Present	77.0	2.57
Absent	23.0	0.94
Cerebrovascular Accident, %		
Recent (within 2 weeks)	0.2	0.00
Remote (more than 2 weeks)	6.9	2.82
None	92.9	2.15
Cerebrovascular Disease, %		
Present	12.8	3.90
Absent	87.2	1.94
Smoker, %		
Yes, Current	15.3	1.99
Yes, Not Current	47.5	2.42
No	37.2	1.99
Peripheral Vascular Disease, %		
Present	18.0	3.86
Absent	82.0	1.83
Renal Failure, %		
Yes, Dialysis	1.4	9.23
Yes, No Dialysis	5.9	5.51
No Renal Failure	92.7	1.88

[1] Calculated using the Haycock formula (Haycock GB, Schwartz GJ, Wisotsky DH. Geometric method for assessing body surface area. Journal of Pediatrics 1978;93(1):62-22).

Variable	Mean	Relationship with 30-Day Mortality§
Mean Last Creatinine Pre-Op, mg/dL	1.2	0.33
Present	78.0	2.26
Absent	22.0	1.97
Previous Cardiovascular Interventions(CV) Interventions, %		
Yes	25.5	3.07
No	74.5	1.89
Previous Coronary Artery Bypass, %		
Yes	3.8	8.57
No, Other Previous CV Intervention	21.7	2.11
Previous Valve Surgery, %		
Yes	0.20	0.00
No, Other Previous CV Intervention	25.3	3.10
Prior PTCA including Balloon/Atherectomy, %		
Yes	18.6	2.33
No, Other Previous CV Intervention	6.8	5.08
Previous Other Cardiac Intervention (traversing the anterior mediastinum), %		
Yes	2.1	5.15
No, Previous Other CV Intervention	23.4	2.88
Myocardial Infarction, %		
Yes	48.9	3.11
Within 6 Hours	0.9	19.51
7 – 24 Hours	1.8	8.33
1 – 7 Days	20.7	2.73
8 – 21 Days	5.7	3.41
> 21 Days	19.8	2.19
No MI	51.1	1.32
Congestive Heart Failure, %		
Present	17.1	4.69
Absent	82.9	1.68
Angina, %		
Present	88.5	2.26
Absent	11.5	1.69
Cardiogenic Shock, %		
Present	2.2	15.53
Refractory Shock	0.2	30.00
Hemodynamic Instability	2.0	13.98
Absent	97.8	1.89
Arrhythmia, %		
Present	9.1	5.26
Absent	90.9	1.89
Pre-Operative Digitalis, %		
Given	4.0	5.46
Not Given	96.0	2.06
Pre-Operative Nitrates, %		
Given	20.2	3.87
Not Given	79.8	1.77

Variable	Mean	Relationship with 30-Day Mortality§
Pre-Operative Anticoagulants, %		
Given	37.8	3.51
Not Given	62.2	1.40
Pre-Operative Diuretics, %		
Given	20.0	4.23
Not Given	80.0	1.68
Pre-Operative Steroids, %		
Given	2.6	5.08
Not Given	97.4	2.12
No. of Diseased Coronary Vessels, %		
None	0.2	0.00
One	4.7	2.34
Two	20.3	1.71
Three	74.9	2.32
Left Main Disease > 50%, %		
Yes	30.1	3.18
No	70.0	1.77
Ejection Fraction (EF) Measured, %		
Yes	95.3	2.26
No	4.7	0.92
Mean EF Given Measured, %	48.9	-6.10
Status of Procedure, %		
Elective	34.0	0.77
Urgent	62.0	2.49
Emergent	3.7	9.88
Salvage	0.2	11.11
Intra-Aortic Balloon Pump Used, %		
Yes, Pre-Op	9.3	8.14
Yes, Intra-Op	1.4	18.18
Yes, Post-Op	0.3	20.00
No	88.9	1.25

MULTIVARIATE RELATIONSHIPS BETWEEN MORTALITY AND RISK FACTORS

Mass-DAC first examined the frequency distributions of each risk factor listed in Table 6 by hospital in order to assess how variable the distributions were among the 13 institutions. This was accomplished by graphically displaying the reported prevalence of each of the risk factors (graphs not shown). The simultaneous relationship between 30-day mortality and the risk factors was examined using regression modeling.

Hierarchical Logistic Regression

Based on expert opinion provided to Mass-DAC by the Advisory Committees, clinical experience, and a review of the literature, Mass-DAC identified a set of risk factors measured prior to surgery to include in a regression model. Because hospitals treat different numbers of patients and have different sets of expertise, the risk of mortality between two patients having exactly the same risk factors prior to surgery treated in two different cardiac surgery programs may differ. The statistical model used to calculate mortality rates in this report, a hierarchical logistic regression model, permits such differences in baseline mortality rates across the cardiac surgery programs in the Commonwealth**.** The model assumes that the log-odds of 30-day mortality is linearly related to the set of risk factors (Equation 1) and permits baseline risk to vary across hospitals (Equation 2):

$$\text{Log-Odds}[\text{Probability}(\text{Dead at 30 days})] = \beta_{0i} + \beta(\text{Risk Factors}) \qquad (1)$$

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

where "i" denotes hospital.

Table 6 describes the mean and adjusted odds ratios for each risk factor using the hierarchical logistic regression model. For example, a mean of 74.5% indicates that males accounted for 74.5% of all CABG surgery admissions. The odds ratio of 0.60 for males indicates that males are 0.60 times as likely as females to die within 30-days of CABG surgery. In contrast, patients having a myocardial infarction within 6 hours of CABG surgery are almost 10 times more likely to die within 30-days than patients not having any myocardial infarction. The hierarchical logistic regression model resulted in an estimate of

between-hospital variation in the log-odds of mortality of $(0.205)^2$ [95% interval: $(0.026)^2$ to $(0.492)^2$] and of between-hospital average log-odds of mortality of -6.75 [95% interval: -7.793 to -5.884].

Table 6: Mean and Adjusted Odds Ratios of 30-Day Mortality Following Isolated CABG Surgery in Adults in the Commonwealth of Massachusetts in 2002. Based on 4,603 surgeries with 101 deaths. Between-Hospital variance (log-odds scale): $(0.205)^2$ [95% Interval: $(0.026)^2$ to $(0.492)^2$].

Risk Factor	Mean (%)	Hierarchical Logistic Regression	
		Odds Ratio	95% Probability Interval
Years greater than 65§	1.5	1.05	1.02, 1.07
Male	74.5	0.60	0.39, 0.96
Renal Failure	7.3	2.39	1.32, 3.93
Diabetes Mellitus	38.0	1.17	0.72, 1.76
Hypertension	77.0	2.91	1.35, 6.26
Peripheral Vascular Disease	18.0	1.73	1.05, 2.66
Prior CABG surgery	3.8	5.83	2.83, 10.11
Prior Percutaneous Transluminal Coronary Angioplasty Intervention (PTCA)	18.6	0.87	0.48, 1.44
Cardiogenic Shock	2.2	3.16	1.29, 6.45
Ejection Fraction (Ref = ≥ 40%)			
< 30% or missing	12.8	1.48	0.79, 2.44
30 - 39	11.7	1.33	0.68, 2.27
Myocardial Infarction (MI) (Ref = None)			
Within 6 Hours	0.9	9.89	2.44, 26.63
7 – 24 Hours	1.8	3.72	1.15, 8.68
1 – 7 Days	20.7	1.10	0.57, 1.90
8 – 21 Days	5.7	1.45	0.56, 2.96
> 21 Days	19.8	1.43	0.72, 2.54
Status of CABG (Ref = Elective)			
Urgent	62.0	2.55	1.29, 4.81
Emergent/Salvage	3.7	2.61	0.79, 6.44
Pre-Op Intra-Aortic Balloon Pump	9.3	2.57	1.40, 4.37

§Represents number of years over age 65 at time of surgery.
A non-hierarchical regression model that included the risk factors listed here resulted in an ROC area of 0.831 and acceptable model fit (goodness-of-fit $\chi^2 = 6.795$ on 8 degrees of freedom).

STANDARDIZED MORTALITY INCIDENCE RATES (SMIR)

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

1. Let $Y_{ij} = 1$ if the j^{th} patient undergoing isolated CABG surgery in the i^{th} cardiac surgery program died within 30-days of surgery and 0 otherwise, and n_i the total number of isolated CABG cases at the institution in 2002. We estimated the model specified in Equations (1) and (2) using the Risk Factors in Table 6.
2. The "expected" mortality rate at institution "i" is: $1/n_i \sum_j \text{logit}^{-1}[\mu + \beta(\text{Risk Factors})]$. This is the mortality rate expected using the mortality intensity for the entire state.
3. The "projected" mortality rate at institution "i" is: $1/n_i \sum_j \text{logit}^{-1}[\beta_{0i} + \beta(\text{Risk Factors})]$. This is interpreted as the mortality rate projected for the i^{th} hospital today given its case-mix and quality in 2002. Because the model assumes that the probability of dying is greater than 0, then the adjusted estimate must be greater than 0.
4. The Massachusetts unadjusted rate is: $Y = 100 \times (\sum_{ij} Y_{ij})/\sum_i n_i = 2.19$.
5. The standardized mortality incidence rate (SMIR) at institution "i" is:
$$2.19 \times (\text{projected})/(\text{expected}).$$
6. Ninety-five percent probability intervals were calculated for each cardiac program's SMIR.

An implication of this procedure is that the SMIR must be larger than zero and must be less than one. A SMIR is the 30-day mortality rate projected for the hospital, after adjusting for the mortality rate expected in hospital. **The SMIR may be interpreted as the mortality rate projected at the hospital today if hospital quality remained the same as in 2002.** The 95% probability interval is used to characterize the likely values of the true SMIR for the hospital. The true SMIR is contained between the lower and upper end of the interval with 95% probability.

Each hospital's SMIR should **only be interpreted** in context of its probability interval. If the 95% probability interval includes the unadjusted state rate of 2.19, then the hospital's

SMIR cannot be shown to be different from what was expected. If the probability interval excludes 2.19, then the hospital's SMIR is "different" from what was expected. In this case, if the upper limit of the probability interval is lower than 2.19, then fewer patients than expected died; if the lower limit of the probability interval is higher than 2.19, then more patients than expected died.

Approach to Parameter and Interval Estimation. The SMIR is a ratio of two random variables, multiplied by a constant. The numerator (projected mortality at the i^{th} hospital) and the denominator (expected mortality at the i^{th} hospital) are, respectively,

$$\text{(Projected Mortality)}_i = 1/n_i \sum_i E(Y_{ij} \mid \text{Risk Factors}, \beta_{0i}, \beta, \mu, \tau^2)$$
$$= 1/n_i \sum_i E(Y_{ij} \mid \text{Risk Factors}, \beta_{0i}, \beta) \text{ by conditional independence}$$

$$\text{(Expected Mortality)}_i = 1/n_i \int \sum_i E(Y_{ij} \mid \text{Risk Factors}, \beta_{0i}, \beta, \mu, \tau^2) f(\beta_{0i} \mid \mu, \tau^2) \partial\beta_{0i}$$
$$= 1/n_i \sum_i E(Y_{ij} \mid \text{Risk Factors}, \beta, \mu, \tau^2)$$

where the summation is taken over all CABG patients in the hospital and the integral is taken over β_{0i}. The SMIR for the i^{th} hospital is thus

$$(\text{SMIR})_i = 2.19 \times \sum_i E(Y_{ij} \mid \text{Risk Factors}, \beta_{0i}, \beta) / \sum_i E(Y_{ij} \mid \text{Risk Factors}, \beta, \mu, \tau^2).$$

There is no simple closed-form solution for the estimator of the SMIR and for its corresponding probability interval. Models were estimated using Gibbs sampling, implemented in the BUGS software. An initial burn-in of 2,000 iterations was used and parameter estimates were based on a subsequent 5,000 draws. At each draw of the parameter estimates, e.g., a draw of $\{\beta_{01}, \beta_{02}, \ldots, \beta_{013}, \beta, \mu, \text{ and } \tau^2\}$, a SMIR was calculated for each institution. Ninety-five percent probability intervals were obtained through identification of the 2.5^{th} and 97.5^{th} percentiles of the 5,000 SMIRs.

Figure 1 displays the SMIRs for 2002 in the Commonwealth. The black vertical line depicts the unadjusted state rate of 2.19. Listed in the figure are the number of CABG cases and the corresponding estimated SMIR for each hospital. The white vertical line in each bar depicts the SMIR for the hospital. The figure indicates that after adjusting for presenting risk, it cannot be shown that **statistical differences** exist between projected and expected mortality for each hospital, i.e., the intervals indicate all hospitals contain the Commonwealth average of 2.19%.

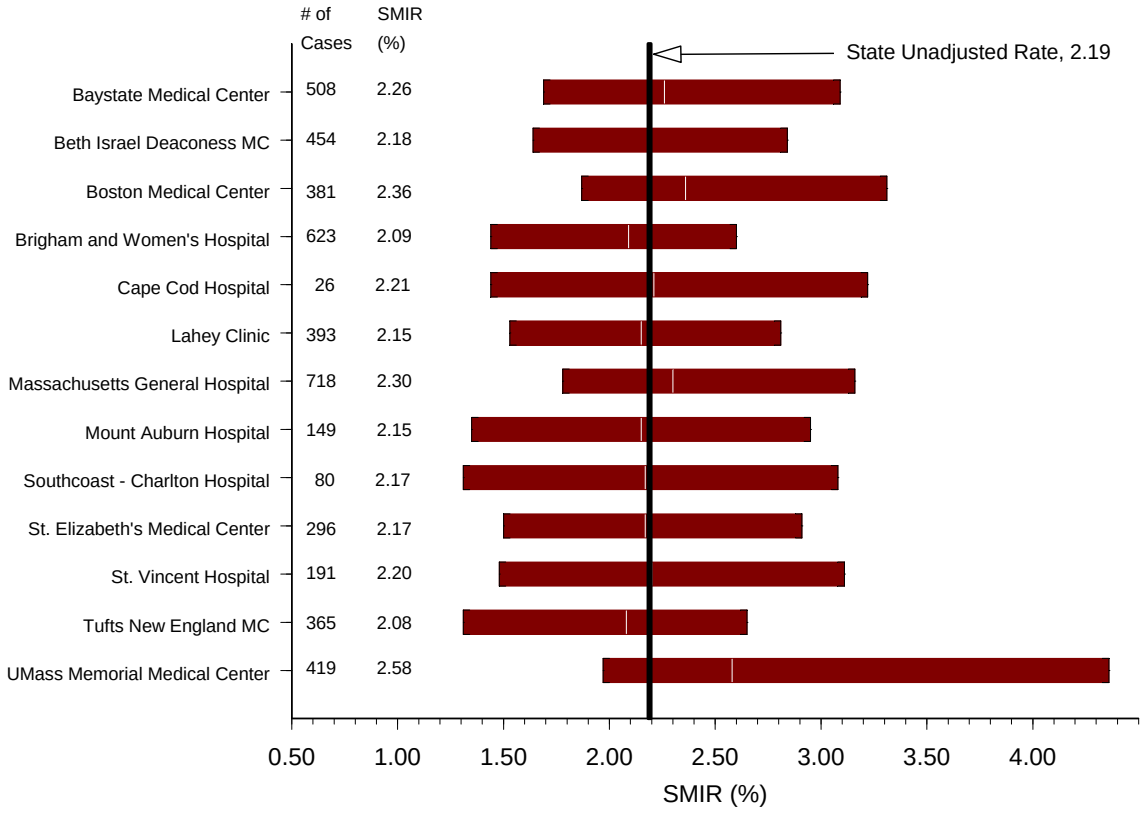
Sensitivity Analyses

Because it is important to determine whether the conclusions made on the basis of a statistical model depend on, or are sensitive to, assumptions associated with the model, Mass-DAC undertook several sensitivity analyses. These analyses involved assessing whether the conclusions changed when "reasonable" changes were made to the analytic model. Mass-DAC made two specific types of changes.

First, a hierarchical logistic regression model that utilized fewer risk factors than those listed in Table 6 was fitted and the SMIRs were re-estimated. The risk factors were selected to mimic those contained in the New York Model (see Adult Cardiac Surgery in New York State 1999-2001, New York State Department of Health, April 2004) and included 14 predictors. The substantive conclusions did not change – there were no statistical differences among hospitals on the basis of the SMIRs.

Second, because there are only 13 cardiac surgery programs in the Commonwealth, the degree of prior belief regarding the amount of heterogeneity among hospitals may influence conclusions. Mass-DAC re-computed the SMIRs when changing this prior belief. The substantive conclusions remained the same – **no statistical differences** could be found between projected and expected mortality, i.e., the intervals show all hospital intervals contain the state rate of 2.19%.

Figure 1. Ninety-Five Percent Probability Intervals for Standardized Mortality Incidence Rates (SMIRs) Following Isolated CABG Surgery in the Commonwealth of Massachusetts, 2002. # of Cases refers to the number of Isolated CABG surgery admissions. The black vertical line denotes unadjusted state 30-day mortality rate.



ADVISORY COMMITTEES

Mass-DAC gratefully acknowledges the support from members of several Advisory Committees who have donated their time to improve the quality of cardiac care in the Commonwealth. Mass-DAC is also indebted to: Kalon Ho, M.D., M.Sc., Beth Israel Deaconess Medical Center (Interventional Cardiology) for valuable clinical expertise; Alan Zaslavsky, Ph.D., for statistical advice; Marc Ciriello, B.A., for editorial comments; and to the Massachusetts Cardiac Surgery Data Managers for their data collection efforts – their attention to detail has contributed enormously to this initiative.

Massachusetts Cardiac Care Quality Advisory Commission develops standards and criteria to be used by the Department of Public Health and Mass-DAC for the purpose of collecting, monitoring, and validating patient specific outcome data from all hospitals in the Commonwealth of Massachusetts performing open heart surgery or angioplasty.

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Appendix 1 – Procedure Identification Guidelines for Adult Cardiac Surgery

Appendix 1: Procedure Identification Guidelines for Adult Cardiac Surgery. New York State refers to classification of cardiac surgery procedures used in that State's public reporting system. *Refers to the National STS Procedure ID Table.

Procedure	Mass-DAC	New York State	STS*
Maze: Open heart approach	"Other"	All Maze procedures are excluded	"Other"
Maze: Closed epicardial approach and radio frequency	"CABG"		"Other"
Implantable Cardioverter Defibrillator (ICD)	"Other"	"CABG"	"Other"
Ventricular lead insertion for ICD	"CABG"	"CABG"	"Other"
Pacemaker lead insertions	"CABG"	"CABG"	"CABG"
Lung biopsy	Case by case basis	"CABG"	"Other"
Patent Foramen Ovale Closure	"CABG"	"CABG"	"Other"
Femoral Artery Procedures	"CABG"	"CABG"	"Other"
Transmyocardial Revascularization	"Other"	"CABG"	"Other"
Opening of the right atrium for tumor resection	"Other"	"Other"	"Other"

Appendix 2 – STS Data Abstraction Tool Version 2.35

The Society of Thoracic Surgeons
Adult Cardiac Surgery Database
Data Collection Form

A. Administrative

Participant ID: |___|___|___|___|___|

B. Demographics

Patient Medical Record Number: _not harvested____

Last Name: _____not harvested_____ First: ____not harvested_ MI: _nh_

Date of Birth: __ __/__ __/__ __ __ __ (mm/dd/yyyy)

Gender: Male Female

Race: Caucasian Black Hispanic Asian Native American Other

Social Security (or National ID) Number: _not harvested____

ZIP or Postal Code: _____

Referring Cardiologist's Name: ____not harvested_____

Referring Physician's Name: ___not harvested_____

C. Hospitalization

Hospital Name: _____

Primary Payor: _____

Same Day Elective Admission: *No* *Yes*

Date of - Admission: __ __/__ __/__ __ __ __ Surgery: __ __/__ __/__ __ __ __ Discharge: __ __/__ __/__ __ __ __

D. Pre-Operative Risk Factors

Weight: _____ (kg) Height: _____ (cm)

Smoker: *No* *Yes* → Current Smoker: *No* *Yes*

Family History of CAD: *No* *Yes*

Diabetes: *No* *Yes* → Diabetes Control: None Diet Oral Insulin

Hypercholesterolemia: *No* *Yes*

Renal Failure: *No* *Yes* → Dialysis: *No* *Yes*

Last Creatinine Preop: _____

Hypertension: *No* *Yes*

Cerebrovascular Accident: *No* *Yes* → When: Recent (<= 2 weeks) Remote (> 2 weeks)

Infectious Endocarditis: *No* *Yes* → Infectious Endocarditis Type: Treated Active

Chronic Lung Disease: *No* Mild Moderate Severe

Immunosuppressive Trtment: *No* *Yes*

Peripheral Vascular Disease: *No* *Yes*

Cerebrovascular Disease: *No* *Yes* → CVD Type: Coma CVA RIND TIA Non Invasive > 75%

E. Previous Interventions

Previous CV Interventions: *No* *Yes*

# of Prior Cardiac Operations - Requiring Cardiopulmonary Bypass: _____ Without Cardiopulmonary Bypass: _____

Previous Surgery - Coronary Artery Bypass: *No* *Yes* Valve: *No* *Yes* Prev Oth Cardiac: *No* *Yes*

Prior PTCA incl Balloon, Ather, +/or Stent: *No* *Yes* → Interval: <= 6 hours > 6 hours → Prev Stent Placement: *No* *Yes*

Thrombolysis: *No* *Yes* → Thrombolysis Interval: <= 6 hours > 6 hours

Previous Balloon Valvuloplasty: *No* *Yes*

F. Pre Operative Cardiac Status

Myocardial Infarction: *No* *Yes* → When: <= 6 hours > 6 hours but <24 hours 1 - 7 days 8 - 21 days > 21 days

Congestive Heart Failure: *No* *Yes*

Angina: No Yes →Type: Stable Unstable↓

Unstable Type: Rest Angina New Class 3 Recent Accel Variant Angina Non-Q MI Post- Infarct Angina

Cardiogenic Shock: *No* *Yes* → Type: Refractory Shock Hemodynamic Instability

Resuscitation: *No* *Yes*

Arrhythmia: *No* *Yes* → Type: Sust VT/VF Heart Block AFib/Flutter

Classification: CCS: 0 I II III IV NYHA: I II III IV

G. Pre Operative Medications

Digitalis: *No* *Yes* Beta Blockers: *No* *Yes* Nitrates – I.V.: *No* *Yes* Anticoagulants: *No* *Yes*

Diuretics: *No* *Yes* Inotropic Agents: *No* *Yes* Steroids: *No* *Yes* Aspirin: *No* *Yes*

H. Pre Operative Hemodynamics and Cath

Number of Diseased Coronary Vessels: None One Two Three (**Note: LM Disease (>50%) counts for two: LAD+CFX)**

Left Main Disease > 50%: *No* *Yes*

Hemodynamic Data - Ejection Fraction: _____ → Method: None LV gram Radionucleotide Estimate ECHO

Hemodynamic Data - Pulmonary Artery Mean Pressure: _____

Aortic Stenosis:	*No* *Yes*	Insufficiency:	0=None	1=Trivial	2=Mild	3= Moderate	4= Severe
Mitral Stenosis:	*No* *Yes*	Insufficiency:	0=None	1=Trivial	2=Mild	3= Moderate	4= Severe
Tricuspid Stenosis:	*No* *Yes*	Insufficiency:	0=None	1=Trivial	2=Mild	3= Moderate	4= Severe
Pulmonic Stenosis:	*No* *Yes*	Insufficiency:	0=None	1=Trivial	2=Mild	3= Moderate	4= Severe

J. Operative

Surgeon's Name: *harvested - removed from harvest files - encrypted - requires surgeon specific permission to be unencrypted*

Status of the procedure:

Elective

Urgent → Reason: AMI IABP Worsening CP CHF Anatomy USA Rest Angina

Emergent → Reason: Shock Circ Support Shock No Circ Support Pulm Edema AEMI Ongoing Ischemia

Salvage

Coronary Artery Bypass: *No* *Yes*

Aortic:	Mitral:	Tricuspid:	Pulmonic:
No	No	No	No
Replacement	Annuloplasty only	Annuloplasty Only	Replacement
Repair/Reconstruction	Replacement	Replacement	Reconstruction
Root Reconstruction Valve Conduit	Reconstruction w/ Annuloplasty	Reconstruction w/ Annuloplasty	
Reconstruction w/ Valve Sparing	Reconstruction w/out Annuloplasty	Reconstruction w/out Annuloplasty	
Resuspension Aortic Valve		Valvectomy	
Resection Sub-Aortic Stenosis			

Minimally Invasive Proc Attempted: *No* *Yes*↓ (complete sect. M) Oth Cardiac Proc: *No* *Yes*↓ (complete sect. N) Oth Non-Cardiac Proc: *No* *Yes*↓ (complete sect. O)

K. Coronary Surgery

Unplanned CABG: *No* *Yes*

Number of Distal Anastomoses - with Arterial Conduits: _____ with Vein Grafts: _____ (continued)

IMAs Used as Grafts: Left IMA Right IMA Both IMAs No IMA Number of IMA Distal Anastomoses: _____

Radial Artery(ies) Used as Grafts: No Radial Left Radial Right Radial Both Radials

Number of - Radial Artery Distal Anastomoses: _____ Gastro-Epiploic Artery Distal Anastomoses: _____

L. Valve Surgery

↓ Key M = Mechanical, B = Bioprosthesis, H = Homograft, A = Autograft, R = Ring

Aortic Prosthesis -	Implant Type:	None	M	B	H	A	R	Implant: _____	Size: _____(mm)
	Explant Type:	None	M	B	H	A	R	Explant: _____	Size: _____(mm)
Mitral Prosthesis -	Implant Type:	None	M	B	H	A	R	Implant: _____	Size: _____(mm)
	Explant Type:	None	M	B	H	A	R	Explant: _____	Size: _____(mm)
Tricuspid Prosthesis -	Implant Type:	None	M	B	H	A	R	Implant: _____	Size: _____(mm)
	Explant Type:	None	M	B	H	A	R	Explant: _____	Size: _____(mm)
Pulmonic Prosthesis -	Implant Type:	None	M	B	H	A	R	Implant: _____	Size: _____(mm)
	Explant Type:	None	M	B	H	A	R	Explant: _____	Size: _____(mm)

Valve Key

Mechanical
M1= ATS Mechanical Prosthesis
M2= Björk-Shiley Convex-Concave Mechanical Prosthesis
M3= Björk-Shiley Monostrut Mechanical Prosthesis
M4= CarboMedics Mechanical Prosthesis
M5= Edwards Tekna Mechanical Prosthesis
M6= Lillehei-Kaster Mechanical Prosthesis
M7= Medtronic-Hall Mechanical Prosthesis
M8= OmniCarbon Mechanical Prosthesis
M9= OmniScience Mechanical Prosthesis
M10= On-X Mechanical Prosthesis
M11= Sorin Bicarbon (Baxter Mira) Mechanical Prosthesis
M12= Sorin Monoleaflet Allcarbon Mechanical Prosthesis
M13= St. Jude Medical Mechanical Prosthesis
M14= Starr-Edwards Caged-Ball Prosthesis
M15= Ultracor Mechanical Prosthesis

Bioprosthetic
B1= Baxter Prima Plus Stentless Porcine Bioprosthesis
B2= Baxter Prima Stentless Porcine Bioprosthesis
B3= Biocor Porcine Bioprosthesis
B4= Biocor Stentless Porcine Bioprosthesis
B5= CarboMedics PhotoFix Pericardial Bioprosthesis
B6= Carpentier-Edwards Pericardial Bioprosthesis
B7= Carpentier-Edwards Standard Porcine Bioprosthesis
B8= Carpentier-Edwards Supra-Annular Porcine Bioprosthesis
B9= Cryolife O'Brien Stentless Porcine Bioprosthesis
B10= Hancock Standard Porcine Bioprosthesis
B11= Hancock II Porcine Bioprosthesis
B12= Hancock Modified Orifice Porcine Bioprosthesis
B13= Ionescu-Shiley Pericardial Bioprosthesis
B14= Labcor Stented Porcine Bioprosthesis
B15= Labcor Stentless Porcine Bioprosthesis
B16= Medtronic Freestyle Stentless Porcine Bioprosthesis
B17= Medtronic Intact Porcine Bioprosthesis
B18= Medtronic Mosaic Porcine Bioprosthesis
B19= Mitroflow Pericardial Bioprosthesis
B20= Sorin Pericarbon Stentless Pericardial Bioprosthesis
B21= St. Jude Medical - Toronto SPV Stentless Porcine Bioprosthesis
B22= St. Jude Medical-Bioimplant Porcine Bioprosthesis

Homograft
H1= Homograft Aortic – Subcoronary
H2= Homograft Aortic Root/Cylinder
H3= Homograft Mitral
H4= Homograft Pulmonic Root
H5= Cryolife Homograft

Autograft
A1= Autograft Pulmonic Root

Ring
R1= Carpentier-Edwards Classic Ring
R2= Carpentier-Edwards Physio Ring
R3= Cosgrove-Edwards Ring
R4= Medtronic Sculptor Ring
R5= Medtronic-Duran Ring
R6= Sorin-Puig-Messana Ring
R7= St. Jude Medical Sequin Ring

777= Other

M. Minimally Invasive

Primary Indication for minimally Invasive approach: Surg/Pat Choice Contrained Std Approach Comb Cath Intervention

Primary Incision: (Sternotomy) Full Partial Transverse (Parasternal) Right Vertical Left Vertical
(Thoracotomy) Right Anterior Left Anterior Posterolateral Xiphoid Epigastric Subcostal

Total # of Incisions: _____ Conversion to Stnd Incision: *No* *Yes* → Indication: Exposure Bleeding Rhythm Hypotension Conduit

Cardiopulmonary Bypass Used: No Yes →Cannulation Meth: Aorta and Fem/Jug Vein Fem Art and Fem/Jug Vein Aorta and Atrial/Caval Fem Art and Atrial/Caval Other

Aortic Occlusion Method: None Cross-clamp Balloon Occlusion

Intracoronary Shunt used during distal anastomoses: *No* *Yes*

Cumulative Ischemic Time (minutes) for LAD system: _____ RCA system: _____ CFX: _____

Suture Technique: Running Interrupted Stapler Combination

Vessel Stabilization Technique: None Suture Snare Suction Device Compression Other

Technique of IMA Harvest: None Direct Vision Thorascopy Combination

Acute Flow Patency Assess of Grafts (Periop): None IntaOp Doppler IntraOp Angio Postop Angio Postop Doppler

N. Other Cardiac Procedures

No	Yes	Left Ventricular Aneurysm Repair	No	Yes	Ventricular Septal Defect Repair	No	Yes	Atrial Septal Defect Repair
No	Yes	Batista	No	Yes	Congenital Defect Repair			
No	Yes	Transmyocard Laser Revasc	No	Yes	Cardiac Trauma	No	Yes	Cardiac Transplant
No	Yes	Permanent Pacemaker	No	Yes	Autom Impl Cardioverter Defibrillator	No	Yes	Other

O. Other Non Cardiac Procedures

No Yes Aortic Aneurysm No Yes Carotid Endarterectomy No Yes Other Vascular No Yes Other Thoracic

P. CPB and Support

Cross Clamp Time (min): _____ Perfusion Time (min): _____ Cardioplegia: No Yes

IABP No Yes → When Inserted: Preop Intraop Postop

➥ Indication: Hemodynamic Instab PTCA Support Unst. Angina CPB Wean Prophylatic

Ventricular Assist Device: No Yes

Q. Post Operative

Blood Products Used: No Yes Number of Hours Ventilated Postop: _____

R. Complications (in hospital)

Complications: No Yes

Operative	No	Yes	ReOperation for Bleeding	Infection	No	Yes	Infection - Sternum - Deep
	No	Yes	ReOperation for Valvular Dysfunction		No	Yes	Thoracotomy
	No	Yes	ReOperation for Graft Occlusion		No	Yes	Leg
	No	Yes	ReOperation for Other Cardiac Problem		No	Yes	Septicemia
	No	Yes	ReOperation for Other Non Cardiac Problem		No	Yes	Urinary Tract Infection
	No	Yes	Perioperative Myocardial Infarction				
Neurologic	No	Yes	Stroke	Pulmonary	No	Yes	Prolonged Ventilation
	No	Yes	Transient		No	Yes	Pulmonary Embolism
	No	Yes	Continuous Coma >=24Hrs		No	Yes	Pneumonia
Renal	No	Yes	Renal Failure	Vascular	No	Yes	Vascular - Aortic Dissection
					No	Yes	Illiac/Femoral Dissection
					No	Yes	Acute Limb Ischemia
Other	No	Yes	Heart Block		No	Yes	Gastro-Intestinal Complic.
	No	Yes	Cardiac Arrest		No	Yes	Multi-System Failure
	No	Yes	Anticoagulant Complication		No	Yes	Atrial Fibrillation
	No	Yes	Tamponade				

S. Mortality

Discharge Status: Alive Dead Status at 30 days after surgery: Alive Dead

Mortality - Date __ __/__ __/__ __ __ __ (mm/dd/yyyy) Location of Death: OR Hospital Home Other Facility

Primary Cause of Death (select only one): Cardiac Neurological Renal Vascular Infection Pulmonary Valvular Other

Mortality - Operative Death: No Yes

T. Readmission

Readmit <=30 Days from Date of Procedure: No Yes↓

Readmission Reason: Anticoagulant Compl Arrhythmias CHF Incisional Complication MI/Recurrent Angina

Pericardial Effusion/Tamponade Pneumonia Respiratory Complication Valve Dysfunction Other

Appendix 3 – STS Data Abstraction Tool Version 2.41

The Society of Thoracic Surgeons
Adult Cardiac Surgery Database
Data Collection Form

Version 2.41

A. Administrative

Participant ID: |___|___|___|___|___| Cost Link Field: |_____| Optional STS Trial Link Number: |___|___|___|___|___| Optional

B. Demographics

Patient Medical Record Number: _____ not harvested

Last Name: _____ First: _____ MI: ____ not harvested

Date of Birth: __ __/__ __/__ __ __ __ optional harvest Age: _____ system calculation

Gender: (Male) (Female)

Race: (Caucasian) (Black) (Hispanic) (Asian) (Native American) (Other)

Social Security (or National ID) Number: _____ not harvested

ZIP or Postal Code: _____ optional harvest

Referring Cardiologist's Name: _____ not harvested Referring Physician's Name: _____ not harvested

C. Hospitalization

Hospital Name: _____ controlled list Primary Payor: _____ not harvested

Date of Admission: __ __/__ __/__ __ __ __ Date of Surgery: __ __/__ __/__ __ __ __ Date of Discharge: __ __/__ __/__ __ __ __

Same Day Elective Admission: No Yes

Initial ICU Hours:_____ Readmn to ICU: No Yes → if yes, Additional ICU Hours _____ Total Hours in ICU:_____ calculated

D. Pre-Operative Risk Factors

Weight: _____ (kg) Height: _____ (cm)

Smoker: No Yes → if yes, Current Smoker: No Yes

Family History of CAD: No Yes

Diabetes: No Yes → if yes, select one: Diabetes Control: (None) (Diet) (Oral) (Insulin)

Hypercholesterolemia: No Yes

Last Creatinine Preop: _____

Renal Failure: No Yes → if yes, Dialysis: No Yes

Hypertension: No Yes

Cerebrovascular Accident: No Yes → if yes, When: (Recent <= 2 weeks) (Remote > 2 weeks)

Infectious Endocarditis: No Yes → If yes, Infectious Endocarditis Type: (Treated) (Active)

Chronic Lung Disease: (No) (Mild) (Moderate) (Severe)

Immunosuppressive Trtment: No Yes

Peripheral Vascular Disease: No Yes

Cerebrovascular Disease: No Yes → if yes, CVD Type: (Coma) (CVA) (RIND) (TIA) (Non Invasive > 75%) (Previous Carotid Surgery)

E. Previous Interventions

Previous CV Interventions: No Yes ↓ if yes, complete this section

# of Prior Cardiac Operations Requiring Cardiopulmonary Bypass: _____ # of Prior Cardiac Operations Without Cardiopulmonary Bypass: _____

Previous Surgery:

Coronary Artery Bypass: No Yes Valve: No Yes Previous Other Cardiac: No Yes

Prior PTCA including Balloon and/or Atherectomy: No Yes → if yes, Interval: <= 6 hours > 6 hours

Previous non-surgical Stent Placement: No Yes → if yes, Interval: <= 6 hours > 6 hours

Thrombolysis: No Yes → if yes, Interval: <= 6 hours > 6 hours

Previous non-surgical Balloon Valvuloplasty: No Yes

F. Pre Operative Cardiac Status

Myocardial Infarction: No Yes → if yes, When: (<= 6 hours) (> 6 hours but <24 hours) (1 - 7 days) (8 - 21 days) (> 21 days)

Congestive Heart Failure: No Yes

Angina: No Yes → if yes, Type: Stable Unstable ↓ if unstable

Unstable Type: (Rest Angina) (New Class 3) (Recent Accel) (Variant Angina) (Non-Q MI) (Post- Infarct Angina)

Cardiogenic Shock: No Yes → if yes Type: (Refractory Shock) (Hemodynamic Instability)

Resuscitation: No Yes

Arrhythmia: No Yes → if yes, Type: (Sust VT/VF) (Heart Block) (AFib/Flutter)

Classification: CCS: 0 I II III IV NYHA: I II III IV

G. Pre Operative Medications

Digitalis: No Yes	Beta Blockers: No Yes	Nitrates – I.V.: No Yes	Anticoagulants: No Yes	Diuretics: No Yes
Inotropic Agents: No Yes	Steroids: No Yes	Aspirin: No Yes	Ace Inhibitors: No Yes	Oth Anti-Platelets: No Yes

H. Pre Operative Hemodynamics and Cath

Number of Diseased Coronary Vessels: (None) (One) (Two) (Three)

Left Main Disease > 50%: No Yes

Ejection Fraction Done? No Yes → if yes, Ejection Fraction: _____ → Method: (LV gram) (Radionucleotide) (Estimate) (ECHO)

Pulmonary Artery Mean Pressure Done? No Yes → if yes, Pulmonary Artery Mean Pressure: _____

Aortic Stenosis: No Yes → If yes, Gradient: _____	Aortic Insufficiency:	0=None 1=Trivial 2=Mild 3= Moderate 4= Severe	
Mitral Stenosis: No Yes	Mitral Insufficiency:	0=None 1=Trivial 2=Mild 3= Moderate 4= Severe	
Tricuspid Stenosis: No Yes	Tricuspid Insufficiency:	0=None 1=Trivial 2=Mild 3= Moderate 4= Severe	
Pulmonic Stenosis: No Yes	Pulmonic Insufficiency:	0=None 1=Trivial 2=Mild 3= Moderate 4= Severe	

J. Operative

Surgeon's Name: _____ controlled list Surgeon Group: _____ controlled list

Status of the procedure:

Emergent Salvage

Emergent → Reason: (Shock Circ Supp) (Shock No Circ Supp) (Pulm Edema) (AEMI) (Ongoing Ischemia) (Valve Dysfnctn) (Aortic Dissection)

Urgent → Reason: (AMI) (IABP) (Worsening CP) (CHF) (Anatomy) (USA) (Rest Angina) (Valve Dysfunction) (Aortic Dissection)

Elective

Coronary Artery Bypass: No Yes (if yes, complete Section K)

Aortic:	Mitral:	Tricuspid:	Pulmonic:
No	No	No	No
Replacement	Annuloplasty only	Annuloplasty Only	Replacement
Repair/Reconstruction	Replacement	Replacement	Reconstruction
Root Reconstruction Valve Conduit	Reconstruction w/ Annuloplasty	Reconstruction w/ Annuloplasty	
Reconstruction w/ Valve Sparing	Reconstruction w/out Annuloplasty	Reconstruction w/out Annuloplasty	
Resuspension Aortic Valve		Valvectomy	
Resection Sub-Aortic Stenosis			

Other Cardiac Procedure: No Yes ↓ (if yes, complete Section N)

Other Non-Cardiac Procedure: No Yes ↓ (if yes, complete Section O)

K. Coronary Surgery

Unplanned CABG: No Yes

Number of Distal Anastomoses with Arterial Conduits: _____

Number of Distal Anastomoses with Vein Grafts: _____

IMAs Used as Grafts: (Left IMA) (Right IMA) (Both IMAs) (No IMA)

Number of IMA Distal Anastomoses: _____

Radial Artery(ies) Used as Grafts: (No Radial) (Left Radial) (Right Radial) (Both Radials)

Number of Radial Artery Distal Anastomoses: _____

Number of Gastro-Epiploic Artery Distal Anastomoses: _____

L. Valve Surgery

↓ Key M = Mechanical, B = Bioprosthesis, H = Homograft, A = Autograft, R = Ring

Aortic Prosthesis -	Implant Type:	None M B H A R	Implant: _____ Size: _____(mm)
	Explant Type:	None M B H A R	Explant: _____ Size: _____(mm)
Mitral Prosthesis -	Implant Type:	None M B H A R	Implant: _____ Size: _____(mm)
	Explant Type:	None M B H A R	Explant: _____ Size: _____(mm)
Tricuspid Prosthesis -	Implant Type:	None M B H A R	Implant: _____ Size: _____(mm)
	Explant Type:	None M B H A R	Explant: _____ Size: _____(mm)
Pulmonic Prosthesis -	Implant Type:	None M B H A R	Implant: _____ Size: _____(mm)
	Explant Type:	None M B H A R	Explant: _____ Size: _____(mm)

Valve Key

Mechanical
M1= ATS Mechanical Prosthesis
M2= Björk-Shiley Convex-Concave Mechanical Prosthesis
M3= Björk-Shiley Monostrut Mechanical Prosthesis
M4= CarboMedics Mechanical Prosthesis
M5= Edwards Tekna Mechanical Prosthesis
M6= Lillehei-Kaster Mechanical Prosthesis
M7= Medtronic-Hall Mechanical Prosthesis
M8= OmniCarbon Mechanical Prosthesis
M9= OmniScience Mechanical Prosthesis
M10= On-X Mechanical Prosthesis
M11= Sorin Bicarbon (Baxter Mira) Mechanical Prosthesis
M12= Sorin Monoleaflet Allcarbon Mechanical Prosthesis
M13= St. Jude Medical Mechanical Prosthesis
M14= Starr-Edwards Caged-Ball Prosthesis
M15= Ultracor Mechanical Prosthesis

Bioprosthetic
B1= Baxter Prima Plus Stentless Porcine Bioprosthesis
B2= Baxter Prima Stentless Porcine Bioprosthesis
B3= Biocor Porcine Bioprosthesis
B4= Biocor Stentless Porcine Bioprosthesis
B5= CarboMedics PhotoFix Pericardial Bioprosthesis
B6= Carpentier-Edwards Pericardial Bioprosthesis
B7= Carpentier-Edwards Standard Porcine Bioprosthesis
B8= Carpentier-Edwards Supra-Annular Porcine Bioprosthesis
B9= Cryolife O'Brien Stentless Porcine Bioprosthesis
B10= Hancock Standard Porcine Bioprosthesis
B11= Hancock II Porcine Bioprosthesis
B12= Hancock Modified Orifice Porcine Bioprosthesis
B13= Ionescu-Shiley Pericardial Bioprosthesis
B14= Labcor Stented Porcine Bioprosthesis
B15= Labcor Stentless Porcine Bioprosthesis
B16= Medtronic Freestyle Stentless Porcine Bioprosthesis
B17= Medtronic Intact Porcine Bioprosthesis
B18= Medtronic Mosaic Porcine Bioprosthesis
B19= Mitroflow Pericardial Bioprosthesis
B20= Sorin Pericarbon Stentless Pericardial Bioprosthesis
B21= St. Jude Medical - Toronto SPV Stentless Porcine Bioprosthesis
B22= St. Jude Medical-Bioimplant Porcine Bioprosthesis

Homograft
H1= Homograft Aortic – Subcoronary
H2= Homograft Aortic Root/Cylinder
H3= Homograft Mitral
H4= Homograft Pulmonic Root
H5= Cryolife Homograft

Autograft
A1= Autograft Pulmonic Root

Ring
R1= Carpentier-Edwards Classic Ring
R2= Carpentier-Edwards Physio Ring
R3= Cosgrove-Edwards Ring
R4= Medtronic Sculptor Ring
R5= Medtronic-Duran Ring
R6= Sorin-Puig-Messana Ring
R7= St. Jude Medical Sequin Ring

777= Other

M. Operative Techniques

Cardiopulmonary Bypass Used: No Yes → if yes, Conversion to CPB: No Yes

Primary Indication for minimally Invasive approach: (Surg/Pat Choice) (ContraindicatedStd Approach) (Comb Cath Intervention)

Primary Incision:

Full Sternotomy Partial Sternotomy Transverse Sternotomy Right Vertical Parasternal Left Vertical Parasternal
Right Anterior Thoracotomy Left Anterior Thoracotomy Posterolateral Thoracotomy Xiphoid Epigastric Subcostal

Total # of Incisions: _____ Conversion to Stnd Incision: No Yes → if yes, Indication: (Exposure) (Bleeding) (Rhythm) (Hypotension) (Conduit)

Cannulation Meth: (Aorta and Fem/Jug Vein) (Fem Art and Fem/Jug Vein) (Aorta and Atrial/Caval) (Fem Art and Atrial/Caval) (Other)

Aortic Occlusion Method: (None) (Cross-clamp) (Balloon Occlusion)

Intracoronary Shunt used during distal anastomoses: No Yes

Suture Technique: (Running) (Interrupted) (Stapler) (Combination)

Vessel Stabilization Technique: (None) (Suture Snare) (Suction Device) (Compression) (Other)

IMA Harvest Technique: (None) (Direct Vision) (Thoracoscopy) (Combination)

Acute Flow Patency Assess of Grafts (Periop): (None) (IntaOp Doppler) (IntraOp Angio) ()Postop Angio) (Postop Doppler)

N. Other Cardiac Procedures

No Yes Left Ventricular Aneurysm Repair	No Yes Vent Septal Defect Repair	No Yes Atrial Septal Defect Repair
No Yes Batista	No Yes SVR	No Yes Congenital Defect Repair
No Yes Transmyocard Laser Revasc	No Yes Cardiac Trauma	No Yes Cardiac Transplant
No Yes Permanent Pacemaker	No Yes AICD	No Yes Other

O. Other Non Cardiac Procedures

No Yes Aortic Aneurysm No Yes Carotid Endarterectomy No Yes Other Vascular No Yes Other Thoracic

P. CPB and Support

Skin Incision Start Time: _____ 24 hour clock Skin Incision Stop Time: _____ 24 hour clock

Cross Clamp Time (min): _____ Perfusion Time (min): _____ Cardioplegia: No Yes

IABP No Yes → if yes, When Inserted: (Preop) (Intraop) (Postop)

If yes, → Indication: (Hemodynamic Instab) (PTCA Support) (Unst. Angina) (CPB Wean) (Prophylatic)

Ventricular Assist Device: No Yes

Q. Post Operative

Blood Products Used: No Yes

Initial # of Hrs Ventilated Postop: _____ Re-intubated During Hosp Stay: No Yes → if yes, Addl Hours Ventilated Postop: _____

Total Hours Ventilated Postop: _____

R. Complications In hospital Complications: No Yes ↓ if yes, at least one complication below must be selected

Operative	No Yes	ReOp for Bleeding/Tamponade	Infection	No Yes	Sternum – Deep
	No Yes	ReOp for Valvular Dysfunction		No Yes	Thoracotomy
	No Yes	ReOp for Graft Occlusion		No Yes	Leg
	No Yes	ReOp for Other Cardiac Problem		No Yes	Septicemia
	No Yes	ReOp for Other Non Cardiac Problem		No Yes	Urinary Tract Infection
	No Yes	Perioperative Myocardial Infarction			
Neurologic	No Yes	Stroke	Pulmonary	No Yes	Prolonged Ventilation
	No Yes	Transient		No Yes	Pulmonary Embolism
	No Yes	Continuous Coma >=24Hrs		No Yes	Pneumonia
Renal	No Yes	Renal Failure	Vascular	No Yes	Vascular - Aortic Dissection
	No Yes	Dialysis		No Yes	Illiac/Femoral Dissection
				No Yes	Acute Limb Ischemia
Other	No Yes	Heart Block			
	No Yes	Cardiac Arrest		No Yes	Gastro-Intestinal Complication
	No Yes	Anticoagulant Complication		No Yes	Multi-System Failure
	No Yes	Tamponade		No Yes	Atrial Fibrillation

S. Discharge (Note: this section is blank if patient dies during initial hospital stay)

Aspirin: No Yes | Ace-Inhibitors: No Yes | Beta Blockers: No Yes | Lipid Lowering: No Yes | Other Anti-Platelets: No Yes

Discharge Location: (Home) (Extended Care/TCU) (Other Hospital) (Nursing Home) (Other)

T. Mortality

Mortality - Mortality: No Yes Discharge Status: Alive Dead Status at 30 days after surgery: Alive Dead

Mortality - Operative Death: No Yes Mortality - Date __ __/__ __/__ __ __ __ (mm/dd/yyyy)

Location of Death: (OR) (Hospital) (Home) (Other Facility)

Primary Cause of Death (select only one): (Cardiac) (Neurological) (Renal) (Vascular) (Infection) (Pulmonary) (Valvular) (Other)

U. Readmission (Note: this section is blank if patient dies during initial hospital stay)

Readmit <=30 Days from Date of Procedure: No Yes↓ if yes, select the most predominate reason

Readmission Reason:

(Anticoagulant Complications)	(Arrhythmias/Heart Block/Pacemaker Insertion/AICD)	(CHF)
(MI/Recurrent Angina)	(Pericardial Effusion/Tamponade)	(Pneumonia/ Respiratory Complication)
(Valve Dysfunction)	(Infection Deep Sternum)	(Infection Leg)
Cardiac Cath)	(PTCA Stent)	(Renal Failure)
TIA)	(Reop for Graft Occlusion)	(Reop for Bleeding)
(Permanent CVA)	(Acute Vascular Complication)	(Other)