

**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
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MASSACHUSETTS DATA ANALYSIS CENTER (MASS-DAC)

Department of Health Care Policy
Harvard Medical School
180 Longwood Avenue
Boston, MA 02115 (www.massdac.org)

Director	
Sharon-Lise T. Normand, Ph.D. Professor of Health Care Policy (Biostatistics), Harvard Medical School Professor, Department of Biostatistics, Harvard School of Public Health	
Program Faculty	Clinical Faculty
Ann Lovett, R.N., M.A. Program Manager Harvard Medical School	David Cohen, M.D., M.Sc. Director of Interventional Cardiology Research Beth Israel Deaconess Medical Center
Robert Wolf, M.S. Biostatistician Programmer/Analyst Harvard Medical School	Barbara McNeil, M.D., Ph.D. Head, Department of Health Care Policy Harvard Medical School
Katya Zelevinsky, B.A. Programmer/Analyst Harvard Medical School	Senior Medical Advisor (Interventional Cardiology) Fred Resnic, M.D., M.Sc. Director, Medical Information Systems Cardiac Catheterization Laboratory Brigham and Women's Hospital
Jarrah Foster, B.S. Research Assistant, Mass-DAC Harvard Medical School Treacy Silverstein, B.S. Research Assistant, Mass-DAC Harvard Medical School	

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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KEY FINDINGS

- In 2002, 7661 cardiac surgeries were performed in Massachusetts hospitals. More than half (60%) of the surgeries were coronary artery bypass graft (CABG) surgery, without any other cardiac surgery.

- Thirteen hospitals performed at least one CABG surgery in 2002. Eleven of the thirteen hospitals had been performing cardiac surgery prior to 2002 while two hospitals performed cardiac surgery for the first time in 2002.

- In the eleven hospitals that performed cardiac surgery prior to 2002, the number of CABG surgeries ranged from 149 cases to 718 during 2002.

- The unadjusted mortality rate within thirty days of isolated CABG surgery in the Commonwealth of Massachusetts during 2002, defined as the number of patients dying within 30-days of surgery divided by the number of patients undergoing CABG surgery, was **2.19%**.

- There were **no statistical differences** in standardized 30-day mortality incidence rates following CABG surgery among the thirteen cardiac surgery programs in the Commonwealth.

INTRODUCTION

What Is In this Report?

This report describes procedures for calculating hospital-specific standardized mortality rates within thirty days following coronary artery bypass graft (**CABG**) surgery performed in Massachusetts hospitals between January 1, 2002 and December 31, 2002. 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. The first cardiac surgery at Southcoast Hospital Group – Charlton Memorial Hospital was performed 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, the first cardiac surgery was not performed until 2003. This document reports hospital-specific standardized mortality incidences rates following CABG surgery for the thirteen cardiac surgery programs in the Commonwealth that performed at least one CABG surgery between January 1, 2002 and December 31, 2002.

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 a sudden development of a clot within a coronary artery, this usually results in a heart attack or myocardial infarction, referred to as 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; however 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.

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 (**Table 1**) in the Commonwealth.

Table 1: Surgical Procedure Type Classification of Adult Cardiac Surgery Admissions in Massachusetts Hospitals, 2002. *Includes one patient lost to follow up who was excluded from the CABG analysis. If multiple cardiac surgeries occur during an admission, admissions are categorized by the primary (initial) surgery.

Surgical Procedure Type	Number of Cardiac Surgery Admissions	Percent 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

Patients undergoing CABG at the same time as valve surgery were not used to determine the hospital mortality rates in this report.

Who Receives CABG Surgery in Massachusetts?

Of patients undergoing Isolated CABG surgery, $\frac{3}{4}$ were males, more than half aged 65 years or older, and the majority white (**Table 2**). A total of 392 patients (9%) resided outside of Massachusetts at the time of their surgery.

Table 2. Age-Sex-Race Distributions for Adult Isolated CABG Surgery Admissions in Massachusetts Hospitals, 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

Why Report Hospital-Specific Mortality Rates?

Quality data can be used to provide useful information to both patients and health care providers, stimulate additional research on cardiovascular disease and existing treatments, and foster improvements in quality of care. This report uses 30-day mortality, defined as death occurring within 30 days of the date of the surgery, regardless of cause, as a measure of hospital quality. While mortality is not the only important endpoint, it was selected as the primary measure of hospital quality because it is serious and unambiguous.

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.

What Data Are Used in the Report?

Massachusetts hospitals are required by law to submit specific information to Mass-DAC. Data included in this report were submitted by hospitals in the Commonwealth that performed CABG surgery between January 1, 2002 and December 31, 2002. All data were rigorously verified by Mass-DAC. This process involved continuous data quality reports to data managers located at each hospital, discussions with the chief of every cardiac surgery department in the Commonwealth, audits of selected chart information by an independent Cardiac Surgery Data Adjudication Committee and by MassPRO, a healthcare quality improvement organization, a review by an external Cardiac Advisory Board, and cross-checked with state administrative databases.

Risk Adjustment for Assessing Hospital Mortality

Specific "risk" factors are known to contribute to heart disease. These include high cholesterol, smoking, high blood pressure, family history of heart disease, diabetes, age, gender, and general health status prior to CABG surgery. Such factors also have an impact on the risk of mortality following surgery. Sicker patients or patients with more health-related risks may be more likely to die following CABG surgery than healthier patients. Moreover, patients who are sicker may be more likely to be treated at particular hospitals, such as teaching hospitals, while patients who are healthier may be more likely to be treated at other hospitals. To compare hospitals fairly, it therefore important to consider differences in patient health prior to surgery.

The statistical process of adjusting for differences in patient sickness prior to their encounter with the health care system 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 mortality rates in this report have been adjusted in order to account for differences in patient health prior to surgery.

Permitting Hospital Differences in Baseline Mortality Risk

Because hospitals treat different numbers of patients and have different sets of expertise, for example, as reflected by the size or experience of their staff, the risk of mortality may differ for two patients having exactly the same risk factors prior to surgery who are treated in two different cardiac surgery programs. 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.

Of the 4603 Isolated CABG surgery admissions in 2002 in Massachusetts, 101 patients (2.19%) died within 30days. **Table 3** lists the frequency, reported in percentages, of important risk factors and the relationship of each risk factor (controlling for all other risk factors) with 30-day mortality following CABG surgery. For example, a frequency of 74.5% indicates that males accounted for 74.5% of all CABG surgery admissions. Odds ratios greater than 1 correspond to increased risk of mortality while those less than 1 correspond to decreased risk of mortality. The odds ratio of 0.60 for males, for example, indicates that males are only 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.

Table 3: Frequency and Adjusted Odds Ratios of 30-Day Mortality Following Isolated CABG Surgery in Adults, Commonwealth of Massachusetts, 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	Frequency (%)	Hierarchical Logistic Regression	
		Adjusted 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 = $\geq 40\%$)			
< 30% or missing	12.8	1.48	0.79, 2.44
30 - 39	11.7	1.33	0.68, 2.27
Myocardial Infarction (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.

STANDARDIZED MORTALITY INCIDENCE RATES (SMIRS)

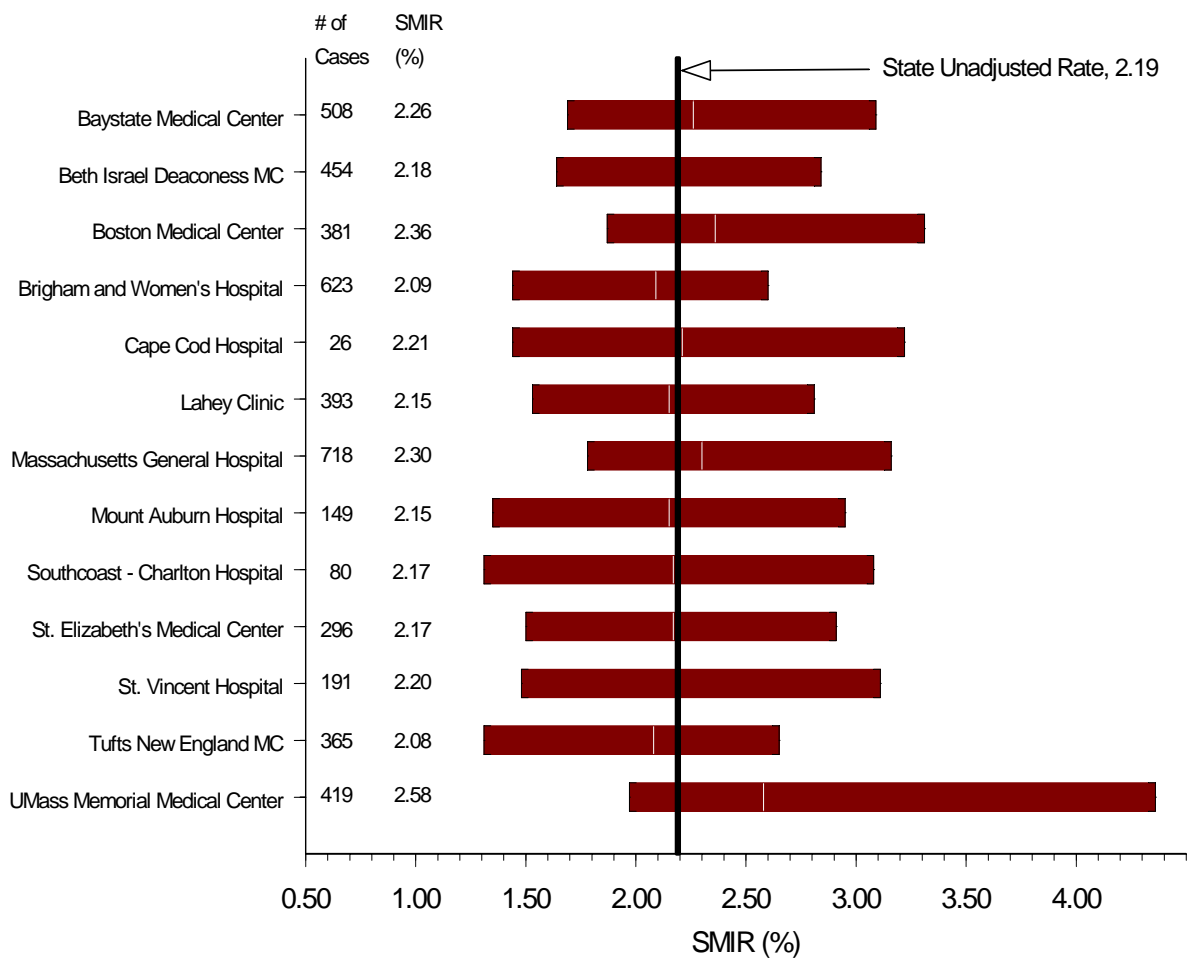
For each hospital in the Commonwealth, Mass-DAC calculated a standardized mortality incidence rate (SMIR) and a corresponding 95% “probability” interval. **The SMIR for a hospital may be interpreted as the projected mortality rate at the hospital today if hospital quality remained the same as in 2002.** 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 the context of its probability interval. If the 95% probability interval includes the unadjusted state rate, then the hospital’s SMIR cannot be shown to be different from what was expected. If the probability interval excludes the unadjusted rate, 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 the unadjusted state rate, then fewer patients than expected died; if the lower limit of the probability interval is higher than the unadjusted rate, then more patients than expected died.

Figure 1 displays the SMIRs and corresponding 95% probability intervals. The solid black vertical line in the figure is the unadjusted state 30-day mortality rate of 2.19%. Listed in the figure are the total number of isolated CABG surgeries for each institution and the corresponding estimated SMIRs. The white vertical line in each bar depicts the estimated SMIR for the hospital. All 95% probability intervals contain the unadjusted state rate. Based on the data collected for surgeries performed in 2002 in the Commonwealth, **no hospital mortality rate could be shown to be statistically different** from what was expected.

Technical details can be found in **Technical Details on Adult Coronary Artery Bypass Graft Surgery in the Commonwealth of Massachusetts: January 1 – December 31, 2002**

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 the unadjusted state 30-day mortality rate.



IMPORTANT DEFINITIONS

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: 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 (as defined by the Massachusetts legislature for the Massachusetts Cardiac Study): 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.

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: A surgery in which the blocked coronary vessels are bypassed with the patients own vessels to improve flow to the heart muscle. Coronary vessels are those vessels that supply the heart muscle with blood and oxygen.

Mitral Valve Repair: Surgical repair of the mitral valve of the heart. The mitral valve is responsible for facilitating the flow of blood from the left atrium into the left ventricle.

Mitral Valve Replacement: A surgical procedure which involves the replacement of the mitral valve of the heart.

Percutaneous Coronary Intervention: 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.

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 can not 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 projected deaths (the number of deaths adjusting for the number of cases treated at the hospital and the hospital case mix) to expected 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.

Surgery: An invasive procedure performed by a surgeon in an operating room that requires anesthesia and a substantial recovery period both in the hospital and after discharge.

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.S., 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.

David Shahian, M.D., Chair
Chairman, Department of Thoracic and
Cardiovascular Surgery
Lahey Clinic
Burlington, MA

Sharon-Lise Normand, Ph.D.
Professor of Health Care Policy (Biostatistics)
Department of Health Care Policy
Harvard Medical School
Boston, MA

Paul Dreyer, Ph.D.
Director, Division of Health Care Quality
Massachusetts Department of Public Health
Boston, MA

John Pastore, M.D.
Director, Echocardiography
St. Elizabeth's Medical Center
Boston, MA

Richard Kuntz, M.D.
Chief Scientific Officer
Harvard Clinical Research Institute
Boston, MA

David Torchiana, M.D.
Chairman and Chief Executive Officer
Massachusetts General Physicians
Organization
Boston, MA

Stanley Lewis, M.D.
Associate Professor of Medicine
Harvard Medical School
Beth Israel Deaconess Medical Center
Boston, MA

Mass-DAC Cardiac Advisory Board advises Mass-DAC on data quality, on identification of risk factors affecting patient outcomes, and on appropriateness, interpretation, and limitations of analytic results.

Shukri Khuri, M.D.
Chief of Surgery
VA-Boston Healthcare Systems
Boston, MA

Thomas Ryan, M.D.
Senior Consultant in Cardiology
Professor of Medicine
Boston University Medical Center
Boston, MA

James Kirshenbaum, M.D.
Co-Director, Clinical Cardiology
Brigham and Women's Hospital
Boston, MA

David Shahian, M.D.
Chairman, Department of Thoracic and
Cardiovascular Surgery
Lahey Clinic
Burlington, MA

James Pastore, M.D.
Director, Echocardiography Laboratory
St. Elizabeth's Medical Center
Boston, MA

David Wennberg, M.D., M.P.H.
Director for Outcomes Research and
Evaluation
Maine Medical Center
Portland, ME

Eric Peterson, M.D., M.P.H.
Director, Cardiovascular Outcomes and
Quality
Duke Clinical Research Institute
Durham, NC

Mass-DAC Cardiac Surgery Data Adjudication Committees review patient-specific data elements and corresponding data documentation submitted by hospitals to Mass-DAC in order to determine validity.

James Rawn, M.D.
Associate Surgeon
Director, Cardiac Surgery Intensive Care Unit
Brigham and Women's Hospital
Boston, MA

David Shahian, M.D.
Chairman, Department of Thoracic and
Cardiovascular Surgery
Lahey Clinic
Burlington, MA

Richard Shemin, M.D.
Professor and Chairman
Department of Cardiothoracic Surgery
Boston Medical Center
Boston, MA