SUPPLEMENTAL MATERIAL

Second Arterial versus Venous Conduits for Multi-Vessel Coronary Artery Bypass Surgery in California

Supplemental Material

Andrew B. Goldstone, MD, PhD, Peter Chiu, MD, MS, Michael Baiocchi, PhD, Hanjay Wang, MD, Bharathi Lingala, PhD, Jack H. Boyd, MD, and Y. Joseph Woo, MD

Supplemental Methods

Author Contributions

ABG, PC, MB, HW, JHB and YJW designed the study. The data were provided by the California Office for Statewide Health Planning and Development. BL output the data into an analyzable format. ABG and MB analyzed the data. ABG prepared the first draft of the manuscript. All authors substantially contributed to discussion of content and revision of the manuscript prior to submission.

Statistical Analysis

In this supplementary statistical analysis section, we will: 1) provide specific details regarding our propensity score matching algorithms; 2) discuss differences in our matched and unmatched populations; 3) substantiate and discuss our use of a matching-based instrumental variable method; 4) elaborate on the sensitivity analyses performed in the study; and 5) list the statistical packages used during the analysis.

Details of propensity score matching algorithm

We chose to use propensity score matching to estimate the average treatment effect on the treated rather than the average treatment effect (the expected effect if all patients in the population received a second arterial conduit) because clinical guidelines maintain that not every patient is a reasonable candidate for a second arterial conduit. We used non-parsimonious logistic regression to estimate each patient's predicted probability of receiving a second arterial conduit (Supplemental Figure 1);[1] the model included all variables presented in Table 1 of the primary manuscript. To accommodate the large sample size, patients were exact-matched with respect to number of diseased vessels, ejection fraction (at 5% intervals beginning at 30%), time interval from myocardial infarction to surgery, emergency status, severity of chronic lung disease, white race, and Hispanic race. Patients were then optimally matched with as many as four control patients matched to each treated patient to balance all baseline covariates.[2] To estimate the average treatment effect on the treated, each control within a matched set was down-weighted by the inverse of the total number of controls within the subclass (all treated patients received a weight of 1) (Supplemental Figure 2).[3]

We used a similar method of propensity score matching to compare recipients of a right internal thoracic artery graft with recipients of a radial artery graft. However, as these patients were already selected to receive a second arterial conduit, we estimated the average treatment effect to determine the impact of all patients receiving a right internal thoracic artery graft instead of a radial artery graft. Optimal matching on the propensity score with as many as 6 controls (radial artery recipients) matched to each treated (right internal thoracic artery recipients) permitted inclusion of almost the entire study population (24 of 5,866 patients excluded, 0.4% of sample). To estimate the average treatment effect, weights were assigned to each patient as discussed by Austin and Stuart.[4]

Comparison of matched versus unmatched population

A contrast of unmatched patients with matched patients for each comparison is included in Supplemental Table 3. In our propensity score-matched comparison of second arterial versus venous conduits, unmatched patients were older, more likely to be female, and had a greater burden of comorbidities. This is not unexpected; not all patients are reasonable candidates for a second arterial conduit and we specifically capped the number of allowable controls per subclass at 4 for that reason. However, with those restrictions we did match 17,930 patients who did not receive a second arterial conduit—but who had similar comorbidity profiles—to patients who did receive a second arterial conduit. Therefore, although our estimate of the effect of a second arterial conduit cannot be generalized to the entire population that undergoes coronary bypass surgery, there are many patients who do not receive second arterial conduits who have similar risk profiles to those who benefit from treatment. A contrast of unmatched patients with matched patients from our instrumental variable analysis demonstrated less imbalance than the aforementioned discussion of matched vs. unmatched patients in the propensity score-matched analysis. In fact, matched patients in the instrumental variable analysis were older than those in our propensity score-matched analysis and had more comorbidities. This difference in patient population may partially explain why our estimate of the effect of a second arterial conduit from our instrumental variable analysis slightly differed from that of our propensity score-matched analysis (additionally, our instrumental variable analysis estimates the complier average causal effect).

Using an instrumental variable approach to address confounding from unobserved covariates

Observational studies represent an alternative to randomized trials to study the comparative effectiveness of different treatments. Unfortunately, a lack of randomization often introduces selection bias and confounding which may obscure the estimation of the true treatment effect. Analytical methods, such as regression, propensity scores, and matching, mitigate confounding owing to measured variables. The California CABG Outcomes Reporting Program (CCORP) is a clinical registry that includes a number of important variables that are not available in administrative discharge databases.[5] Almost all of the variables we use in our surgical practice to determine selection for a second arterial conduit are present in the CCORP. For this reason, propensity score matching was a reasonable strategy for minimizing confounding. However, this method ignores unmeasured confounders that are not present in the CCORP, such as target vessel size and stenosis, and the unmeasurable confounder of frailty. The instrumental variable method was designed to account for unmeasured confounders; conversationally one might say it seeks to find a pseudo-randomized experiment embedded within an observational study.

An instrumental variable method exploits a variable that influences which treatment subjects receive, and only affects outcome through its influence on treatment.[6] For this project, we used individual surgeon practice patterns as a preference-based instrumental variable. We believed a preference-based instrumental variable would be particularly well-suited for this observational study because: 1) the specific treatment a patient receives (second arterial conduit vs. venous conduit) is often determined by the preferences of the surgeon performing the procedure, and 2) for routine surgeries, patients are typically referred to surgeons in a manner that is not informed by severity or complexity of illness. In the case of coronary bypass surgery, a patient who received a second arterial conduit might have received a venous conduit had they been referred to a different surgeon. Surgeon utilization of second arterial conduits ranged from 0% to 100% of their cases (Supplemental Figure 3) and strongly affected the treatment each patient received (F-statistic = 25,282 from first stage least squares model; calculated in R with *ivmodel* package[7]).

An assumption made with instrumental variable methods is that the instrumental variable affects outcomes only through its effect on the treatment received (i.e. there is no direct effect of the instrumental variable on the outcome and there is no unmeasured confounding of the instrumental variable and outcome). This assumption is called the exclusion restriction assumption and cannot be formally tested. With respect to our study, one may argue that surgeons who frequently use arterial conduits improve survival because they are inherently more skilled, or because the care they provide is better than that of surgeons who infrequently or never use arterial conduits. Although this statement cannot be formally proven or disproven, we attempted to test the reasonableness of the assumption with available data. We compared surgeons in our study on outcomes of "out of sample" procedures and patients. That is, we examined 30,266 patients who underwent coronary bypass surgery with concomitant cardiac surgery procedures (e.g. valve, aortic, or mechanical circulatory support) during the study period and beyond (until December 31, 2013). Using multivariable Cox proportional hazards regression, and accounting for clustering of patients within surgeon and within hospital with random effects terms, we found that surgeons with higher rates of arterial conduit use did not significantly affect survival (HR 0.89, 95% CI 0.70 – 1.12, p=0.32). This observation at least partially supports our use of a surgeon-level characteristic as a preference-based instrumental variable because it is compatible with the required assumption that the instrumental variable does not predict different surgeon "skill-levels." Further support for the instrumental variable not violating the exclusion restriction assumption is presented in the manuscript: in a mixed-effects Cox model of survival regressed on the treatment and a random effect for surgeon, the random effect for surgeon exhibited a near-negligible standard deviation. This suggests that in patients undergoing isolated, multi-vessel coronary bypass surgery, there is very little variability between surgeons with respect to their influence on the baseline hazard of death.

We used a matching-based instrumental variable method in our study.[8] Patients who presented to surgeons who use a second arterial conduit in more than 5% of their coronary bypass operations were considered encouraged, while those who presented to surgeons who use a second arterial conduit in less than 5% of coronary bypass operations were considered unencouraged. Given our large sample size, we were able to further strengthen our instrument without overly diminishing statistical power by excluding patients who presented to surgeons who use second arterial conduits in 5% to 20% of their coronary bypass operations. We then performed near-far matching, whereby patients were optimally pair matched to minimize differences in baseline covariates and maximize differences in the instrumental variable (Supplemental Table 5).[8] To estimate the effect of a second arterial conduit on survival and on freedom from major adverse cardiovascular and cerebrovascular events, we used the two-stage residual inclusion method.[9] Residuals were obtained from a least squares model regressing the treatment received on the dichotomous instrument (encouraged vs. unencouraged). The residuals from the first stage were then included as a covariate in a multivariable Cox proportional hazards model that also included the treatment received (second arterial conduit). The estimate for the coefficient of the treatment received represents the point estimate for the

complier average causal effect; 95% confidence intervals were obtained with 10,000 bootstrap replicates with resampling at the matched-pair level.

Sensitivity analysis

As previously mentioned, propensity score matching only helps mitigate confounding due to measured variables. Therefore, we conducted a sensitivity analysis to explore the extent to which the results from our propensity score matching design were robust to unmeasured bias. Through matching, we assume that patients who appear comparable are in fact comparable. However, if unmeasured confounding is present, patients who appear comparable are not always comparable. The gamma sensitivity parameter describes the fold increase in likelihood of receiving treatment between matched individuals.[10,11] In the main manuscript, we present the minimum value of gamma necessary to change our conclusion that the null hypothesis should be rejected. Further, the gamma parameter can be interpreted in terms of two parameters. Lambda controls the relationship between the unobserved bias and treatment assignment, while delta controls the relationship between the unobserved bias and the outcome.[12] We report the values of lambda and delta for the calculated gamma in Table 2 of the manuscript.

Statistical software and packages used to perform the analysis

Data was prepared for analysis in SAS (SAS Institute Inc., Cary, NC) and statistical analyses were performed in R version 3.2.3 (R Foundation, Vienna, Austria). The *survey* package[13] was used to compare baseline characteristics and operative mortality between groups. The Cochrane Armitage test within the *coin* package[14] was used to evaluate trends over time. Survival analyses were performed with the *survival* package.[15] Restricted mean survival time differences were calculated and compared between groups with the *survRM2* package.[16] To evaluate the age-dependent effect of a second arterial conduit on all-cause mortality, a Cox proportional hazards model was fit to the study population with the interaction of a natural spline fit for age (3 knots) and receipt of a second arterial conduit with the *survival* package. Gamma parameters (and the corresponding lambda and delta) were calculated with the *coin* (to output log-rank transformations) and *sensitivitymv* package.[17]

Supplemental Table 1. Definitions of Baseline Characteristics*

Baseline Comorbidity	ICD9-CM Code
Age, Year of Surgery, Sex, Race, Height, Weight, Ejection Fraction, Creatinine, Dialysis, Diabetes mellitus, Hypertension, Peripheral vascular disease, Cerebrovascular disease, Chronic lung disease, Congestive heart failure, Prior myocardial infarction, Prior PCI, Mitral regurgitation, Cardiogenic shock, Cardiopulmonary resuscitation, Immunosuppressed, Surgical status, Redo sternotomy, Number of diseased vessels	Obtained directly from California CABG Outcomes Reporting Program registry – definitions comply with the variable definitions of the Society of Thoracic Surgeons adult cardiac surgery database
Atrial fibrillation/flutter	*Diagnosis codes (from index and prior admissions)* 42731, 42732
Liver disease	*Diagnosis codes (from index and prior admissions)* 700, 701, 7020, 7021, 7022, 7023, 7030, 7031, 7032, 7033, 7041, 7042, 7043, 7044, 7049, 7051, 7052, 7053, 7054, 7059, 706, 7070, 7071, 709, 4560, 4561, 4562, 45620, 45621, 4563, 4564, 4565, 4566, 4568, 570, 5710, 5711, 5712, 5713, 57140, 57141, 57142, 57149, 5715, 5716, 5718, 5719, 5720, 5721, 5722, 5723, 5724, 5728, 5730, 5731, 5732, 5733, 5734, 5735, 5738, 7824, 7891, 78959, 7904, 7948, and V427
Cancer	<u>Oropharyngeal cancers</u> *Diagnosis codes (from index and prior admissions)* 1400, 1401, 1403, 1404, 1405, 1406, 1408, 1409, 1410, 1411, 1412, 1413, 1414, 1415, 1416, 1418, 1419, 1420, 1421, 1422, 1428, 1429, 1430, 1431, 1438, 1439, 1440, 1441, 1448, 1449, 1450, 1451, 1452, 1453, 1454, 1455, 1456, 1458, 1459, 1460, 1461, 1462, 1463, 1464, 1465, 1466, 1467, 1468, 1469, 1470, 1471, 1472, 1473, 1478, 1479, 1480, 1481, 1482, 1483, 1488, 1489, 1490, 1491, 1498, and 1499 <u>Gastrointestinal cancers</u> *Diagnosis codes (from index and prior admissions)* 1500, 1501, 1502, 1503, 1504, 1505, 1506, 1508, 1509, 1510, 1511, 15012, 1513, 1514, 1515, 1516, 1518, 1519, 1520, 1521, 1522, 1523, 1528, 1529, 1530, 1531, 1532, 1533, 1534, 1535, 1536, 1537, 1538, 1539, 1540, 1541, 1542, 1543, 1548, 1550, 1551, 1552, 1560, 1561, 1562, 1568, 1569, 1570, 1571, 1572, 1573, 1574, 1578, 1579, 1580, 1588, 1589, 1590, 1591, 1598, and 1599 <u>Respiratory cancers</u> *Diagnosis codes (from index and prior admissions)* 1600, 1601, 1602, 1603, 1604, 1605, 1608, 1609, 161, 1610,

Supplemental Table 1. Definitions of Baseline Characteristics (continued)*

Baseline Comorbidity	ICD9-CM Code
Cancer (continued)	1611, 1612, 1613, 1618, 1619, 162, 1620, 1622, 1623, 1624, 1625, 1628, 1629, 163, 1630, 1631, 1638, 1639, 164, 1640, 1461, 1462, 1463, 1468, 1649, 165, 1650, 1658, and 1659 <u>Bone and connective tissue cancer</u> *Diagnosis codes (from index and prior admissions)* 1700, 1701, 1702, 1703, 1704, 1705, 1706, 1707, 1708, 1709, 1710, 1712, 1713, 1714, 1715, 1716, 1717, 1718, 1719, 1720, 1721, 1722, 1723, 1724, 1725, 1726, 1727, 1728, 1729, 17300, 17301, 17302, 17309, 17310, 17311, 17312, 17319, 17320, 17321, 17322, 17329, 17330, 17331, 17332, 17339, 17340, 17341, 17342, 17349, 17350, 17351, 17352, 17359, 17360, 17361, 17362, 17369, 17370, 17371, 17372, 17379, 17380, 17381, 17382, 17389, 17390, 17391, 17392, 17399, 1740, 1741, 1742, 1743, 1744, 1745, 1746, 1748, 1749, 1750, 1759, 1760, 1761, 1762, 1763, 1764, 1765, 1768, and 1769 <u>Genitourinary cancers</u> *Diagnosis codes (from index and prior admissions)* 179, 1800, 1801, 1808, 1809, 181, 1820, 1821, 1828, 1830, 1832, 1833, 1834, 1835, 1838, 1839, 1840, 1841, 1842, 1843, 1844, 1848, 1849, 185, 1860, 1869, 1871, 1872, 1873, 1874, 1875, 1876, 1877, 1878, 1879, 1880, 1881, 1882, 1883, 1884, 1885, 1886, 1887, 1888, 1889, 1890, 1891, 1892, 1893, 1894, 1898, and 1899 <u>Lymphoid cancers</u> *Diagnosis codes (from index and prior admissions)* 20000, 20001, 20002, 20003, 20004, 20005, 20006, 20007, 20008, 2001, 20010, 20011, 20012, 20013, 20014, 20015, 20016, 20017, 20018, 2002, 20020, 20021, 20022, 20023, 20024, 20025, 20026, 20027, 20028, 20030, 20031, 20032, 20033, 20034, 20035, 20036, 20037, 20038, 20040, 20041, 20042, 20043, 20044, 20045, 20046, 20047, 20048, 20050, 20051, 20052, 20053, 20054, 20055, 20056, 20057, 20058, 20060, 20061, 20062, 20063, 20064, 20065, 20066, 20067, 20068, 20070, 20071, 20072, 20073, 20074, 20075, 20076, 20076, 20077, 20078, 20080, 20081, 20082, 20083, 20084, 20085, 20086, 20087, 20088, 20100, 20101, 20102, 20103, 20104, 20105, 20106, 20107, 20108, 20110, 20111, 20112, 20113, 20114, 20115, 20116, 20117, 20118, 20120, 20121, 20122, 20123, 20124, 20125, 20126, 20127, 20128, 20140, 20141, 20142, 20143, 20144, 20145, 20146, 20147, 20148, 20150, 20151, 20152, 20153, 20154, 20155, 20156, 20157, 20158, 20160, 20161, 20162, 20163, 20164, 20165, 20166, 20167, 20168, 20170, 20171, 20172, 20173, 20174, 20175, 20176, 20177, 20178, 20190, 20191, 20192, 20193, 20194, 20195, 20196, 20197, 20198, 20200, 20201, 20202, 20203, 20204, 20205, 20206, 20207, 20208, 20210, 20211, 20212, 20213, 20214, 20215, 20216, 20217, 20218, 20220, 20221, 20222, 20223, 20224, 20225, 20226, 20227, 20228, 20230, 20231, 20232, 20233, 20234, 20235, 20236, 20237, 20238, 20240, 20241,

Supplemental Table 1. Definitions of Baseline Characteristics (continued)*

Baseline Comorbidity	ICD9-CM Code
Cancer (continued)	20242, 20243, 20244, 20245, 20246, 20247, 20248, 20250, 20251, 20252, 20253, 20254, 20255, 20256, 20257, 20258, 20260, 20261, 20262, 20263, 20264, 20265, 20266, 20267, 20268, 20270, 20271, 20272, 20273, 20274, 20275, 20276, 20277, 20278, 20280, 20281, 20282, 20283, 20284, 20285, 20286, 20287, 20288, 20290, 20291, 20292, 20293, 20294, 20295, 20296, 20297, 20298, 20300, 20301, 20302, 20310, 20311, 20312, 2038, 20380, 20381, and 20382 Hematologic cancers *Diagnosis codes (from index and prior admissions)* 20400, 20401, 20402, 20410, 20411, 20412, 20420, 20421, 20422, 20480, 20481, 20482, 20490, 20491, 20492, 20500, 20501, 20502, 20510, 20511, 20512, 20520, 20521, 20522, 20530, 20531, 20532, 20580, 20581, 20582, 20590, 20591, 20592, 20600, 20601, 20602, 20610, 20611, 20612, 20620, 20621, 20622, 20680, 20681, 20682, 20690, 20691, 20692, 20700, 20701, 20702, 20710, 20711, 20712, 20720, 20721, 20722, 20780, 20781, 20782, 20800, 20801, 20802, 20810, 20811, 20812, 2082, 20820, 20821, 20822, 20880, 20881, 20882, 20890, 20891, 20892, 20900, 20901, 20902, 20903, 20910, 20911, 20912, 20913, 20914, 20915, 20916, 20917, 20920, 20921, 20922, 20923, 20924, 20925, 20926, 20927, 20929, 20930, 20931, 20932, 20933, 20934, 20935, 20936, 20940, 20941, 20942, 20943, 20950, 20951, 20952, 20953, 20954, 20955, 20956, 20957, 20960, 20961, 20962, 20963, 20964, 20965, 20966, 20967, 20969, 20970, 20971, 20972, 20973, 20974, 20975, and 20979 Other cancers *Diagnosis codes (from index and prior admissions)* 1900, 1901, 1902, 1903, 1904, 1905, 1906, 1907, 1908, 1909, 191, 1910, 1911, 1912, 1913, 1914, 1915, 1916, 1917, 1918, 1919, 1920, 1921, 1922, 1923, 1928, 1929, 193, 1940, 1941, 1943, 1944, 1945, 1946, 1948, 1950, 1951, 1952, 1953, 1954, 1955, 1958, 1960, 1961, 1962, 1963, 1965, 1966, 1968, 1969, 1970, 1971, 1972, 1973, 1974, 1975, 1976, 1977, 1978, 1980, 1981, 1982, 1983, 1984, 1985, 1986, 1987, 19881, 19882, 19889, 199, 1990, 1991, and 1992
Osteoporosis	*Diagnosis codes (from index or prior admissions)* 7330, 73300, 73301, 73302, 73303, 73309
Hip fracture	Fractures of the femur *Diagnosis codes (from index or prior admissions)* 82000, 82001, 82002, 82003, 82009, 82010, 82011, 82012, 82013, 82019, 82020, 82021, 82022, 82030, 82031, 82032, 8208, 8209

Supplemental Table 1. Definitions of Baseline Characteristics (continued)*

Baseline Comorbidity	ICD9-CM Code
Hip fracture (continued)	Fractures of the pelvis *Diagnosis codes (from index or prior admissions)* 8080, 8081, 8082, 8083, 80841, 80842, 80843, 80844, 80849, 80851, 80852, 80853, 80854, 80859, 8088, 8089
Malnutrition	*Diagnosis codes (from index or prior admissions)* 260, 261, 262, 2630, 2631, 2632, 2638, 2639, 2699
Anemia	*Diagnosis codes (from index or prior admissions)* 2800, 2801, 2808, 2809, 2810, 2811, 2812, 2813, 2814, 2818, 2819, 2822, 2823, 2828, 2829, 2830, 28310, 28319, 2839, 28409, 28489, 2849, 2850, 2851, 28521, 28522, 28529, 2853, 2858, 2859
Hypothyroidism	*Diagnosis codes (from index or prior admissions)* 244, 2440, 2441, 2442, 2443, 2448, 2449
Asthma	*Diagnosis codes (from index or prior admissions)* 493, 4930, 49300, 49301, 49302, 4931, 49310, 49311, 49312, 49320, 49321, 49322, 4938, 49381, 49382, 4939, 49390, 49391, 49392
Dementia	*Diagnosis codes (from index or prior admissions)* 2900, 290101, 29011, 29012, 29013, 29020, 29021, 2903, 29040, 29041, 29042, 29043, 29410, 29411, 29420, 29421, 3310, 33119, 33182, 2912

*Modified from Chikwe et al. JAMA 2015.

Supplemental Table 2. Definitions of Study Endpoints

Outcome	ICD-9 Codes
Stroke (Days since surgery)	Ischemic *Diagnosis codes (at index or subsequent admissions)* 43301, 43311, 43321, 43331, 43381, 43391, 43401, 43411, and 43491 Hemorrhagic *Diagnosis codes (at index or subsequent admissions)* 430, 431, 4320, 4321, and 4329 Iatrogenic *Diagnosis code (at index or subsequent admissions)* 99702
Myocardial infarction (Days since surgery)	*Diagnosis codes (at index (if not present on admission) or subsequent admissions)* 41001, 41011, 41021, 41031, 41041, 41051, 41061, 41071, 41081, 41091, 41000, 41010, 41020, 41030, 41040, 41050, 41060, 41070, 41080, 41090
Repeat revascularization (Days since surgery)	Surgical revascularization *Procedure codes (from subsequent admissions)* 3610, 3611, 3612, 3613, 3614, 3614, 3615, 3616, 3617, 3619 Percutaneous coronary intervention *Procedure codes (at subsequent admission)* 0066, 1755, 3601, 3602, 3603, 3604, 3605, 3606, 3607, 3608, 3609
Sternal wound infection (Any event within 1 year of surgery)	*Diagnosis and procedure codes (at index or subsequent admissions)* 99859 with: 73000, 73008, 73010, 73018, 73020, 73028, 73080, 73088, 73090, 73098 or with: 99830, 99831, 99832 or with: 8622 or with: 5192
Mortality	From death-linked data

Supplemental Table 3. Baseline Characteristics of Matched vs. Unmatched Patients for Each Comparison*

	Second Arterial Conduit vs. Venous Conduit (Propensity Score)			Second Arterial Conduit vs. Venous Conduit (Near-Far)			Right Internal Thoracic Artery vs. Radial Artery (Propensity Score)		
	Unmatched	Matched		Unmatched	Matched		Unmatched	Matched	
Characteristic	**(N=35,689)**	**(N=23,743)**	**SMD**	**(N=42,450)**	**(N=16,982)**	**SMD**	**(N=24)**	**(N=5,842)**	**SMD**
Age – yr	67.8 ± 10.4	63.4 ± 10.1	0.42	66.0 ± 10.5	66.1 ± 10.5	0.005	61.9 ± 9.9	62.0 ± 10.5	0.009
Year of surgery – yr	2008.2 ± 1.6	2008.1 ± 1.6	0.07	2008.2 ± 1.6	2008.1 ± 1.6	0.03	2008.6 ± 1.7	2008.1 ± 1.6	0.32
Male sex - no. (%)	25120 (70.4)	19813 (83.4)	0.31	31736 (74.8)	13197 (77.7)	0.07	16 (66.7)	4987 (85.4)	0.45
Race - no. (%)									
Unknown	622 (1.7)	303 (1.3)		690 (1.6)	235 (1.4)		0 (0.0)	66 (1.1)	
White	19775 (55.4)	16743 (70.5)		24108 (56.8)	12410 (73.1)		1 (4.2)	4189 (71.7)	
Black	1588 (4.4)	683 (2.9)	0.33	1731 (4.1)	540 (3.2)	0.37	23 (95.8)	123 (2.1)	5.42
Hispanic	7617 (21.3)	2844 (12.0)		8699 (20.5)	1762 (10.4)		0 (0.0)	665 (11.4)	
Asian	4389 (12.3)	2252 (9.5)		5110 (12.0)	1531 (9.0)		0 (0.0)	618 (10.6)	
Native American	82 (0.2)	44 (0.2)		87 (0.2)	39 (0.2)		0 (0.0)	12 (0.2)	
Other	1616 (4.5)	874 (3.7)		2025 (4.8)	465 (2.7)		0 (0.0)	169 (2.9)	
Height – cm	169.0 ± 10.7	172.8 ± 9.7	0.37	170.0 ± 10.5	171.8 ± 10.2	0.17	170.7 ± 13.2	173.3 ± 9.5	0.23
Weight – kg	82.1 ± 18.7	87.5 ± 18.7	0.29	83.7 ± 18.9	85.5 ± 18.7	0.10	104.6 ± 26.5	88.2 ± 18.6	0.72
Ejection fraction - %	51.1 ± 14.0	55.2 ± 12.2	0.31	51.9 ± 13.5	54.8 ± 13.0	0.21	54.0 ± 14.7	55.6 ± 12.1	0.12
Creatinine - mg/dL	1.37 ± 1.31	1.09 ± 0.58	0.27	1.27 ± 1.11	1.23 ± 1.02	0.03	1.03 ± 0.22	1.08 ± 0.54	0.11
Dialysis - no. (%)	2021 (5.7)	223 (0.9)	0.27	1640 (3.9)	604 (3.6)	0.02	0 (0.0)	48 (0.8)	0.13
Diabetes mellitus - no. (%)	17688 (49.6)	8870 (37.4)	0.25	19644 (46.3)	6914 (40.7)	0.11	17 (70.8)	2060 (35.3)	0.76
Hypertension - no. (%)	31469 (88.2)	19689 (82.9)	0.15	5604 (13.2)	2669 (15.7)	0.07	21 (87.5)	4723 (80.8)	0.18
Peripheral vascular disease - no. (%)	5465 (15.3)	2477 (10.4)	0.15	5946 (14.0)	1996 (11.8)	0.07	1 (4.2)	557 (9.5)	0.21
Cerebrovascular disease - no. (%)	5572 (15.6)	2407 (10.1)	0.16	5896 (13.9)	2083 (12.3)	0.05	4 (16.7)	527 (9.0)	0.23
Chronic lung disease - no. (%)									
None	26993 (75.6)	20101 (84.7)		32816 (77.3)	14278 (84.1)		21 (87.5)	4962 (84.9)	
Mild	4506 (12.6)	2432 (10.2)	0.27	5172 (12.2)	1766 (10.4)	0.20	2 (8.3)	590 (10.1)	0.30
Moderate	2349 (6.6)	772 (3.3)		2553 (6.0)	568 (3.3)		0 (0.0)	185 (3.2)	
Severe	1813 (5.1)	438 (1.8)		1881 (4.4)	370 (2.2)		1 (4.2)	103 (1.8)	
Congestive heart failure - no. (%)	27790 (77.9)	21065 (88.7)	0.29	8190 (19.3)	2382 (14.0)	0.14	5 (20.8)	578 (9.9)	0.31
Prior myocardial infarction - no. (%)									
None	17130 (48.0)	13426 (56.5)		21402 (50.4)	9154 (53.9)		11 (45.8)	3321 (56.8)	
>21 days	6065 (17.0)	4195 (17.7)		7262 (17.1)	2998 (17.7)		8 (33.3)	1002 (17.2)	
8 to 21 days	2063 (5.8)	610 (2.6)	0.28	2141 (5.0)	532 (3.1)	0.15	0 (0.0)	143 (2.4)	0.54
1 to 7 days	8577 (24.0)	5118 (21.6)		9843 (23.2)	3852 (22.7)		4 (16.7)	1253 (21.4)	
>6 hrs but <24 hrs	1202 (3.4)	265 (1.1)		1181 (2.8)	286 (1.7)		1 (4.2)	69 (1.1)	
≤6 hrs	583 (1.6)	107 (0.5)		530 (1.2)	160 (0.9)		0 (0.0)	36 (0.6)	

Supplemental Table 3. Baseline Characteristics of Matched vs. Unmatched Patients for Each Comparison (continued)*

	Second Arterial Conduit vs. Venous Conduit (Propensity Score)			Second Arterial Conduit vs. Venous Conduit (Near-Far)			Right Internal Thoracic Artery vs. Radial Artery (Propensity Score)		
	Unmatched	Matched		Unmatched	Matched		Unmatched	Matched	
Characteristic	**(N=35,689)**	**(N=23,743)**	**SMD**	**(N=42,450)**	**(N=16,982)**	**SMD**	**(N=24)**	**(N=5,842)**	**SMD**
Prior PCI - no. (%)			0.09			0.01			0.09
None	27770 (77.8)	18922 (79.7)		33350 (78.6)	13342 (78.6)		19 (79.2)	4672 (80.0)	
>6 hrs	7575 (21.2)	4733 (19.9)		8797 (20.7)	3511 (20.7)		5 (20.8)	1149 (19.7)	
≤6 hrs	346 (1.0)	83 (0.3)		300 (0.7)	129 (0.8)		0 (0.0)	21 (0.4)	
Mitral regurgitation - no. (%)			0.17			0.18			0.68
None	23178 (64.9)	16176 (68.1)		28802 (67.8)	10552 (62.1)		9 (37.5)	3978 (68.1)	
Trivial	3731 (10.5)	3103 (13.1)		4240 (10.0)	2594 (15.3)		6 (25.0)	822 (14.1)	
Mild	5234 (14.7)	2808 (11.8)		5588 (13.2)	2454 (14.5)		7 (29.2)	653 (11.2)	
Moderate	1866 (5.2)	707 (3.0)		1776 (4.2)	797 (4.7)		1 (4.2)	158 (2.7)	
Severe	204 (0.6)	42 (0.2)		182 (0.4)	64 (0.4)		0 (0.0)	11 (0.2)	
Cardiogenic shock - no. (%)	545 (1.5)	89 (0.4)	0.12	481 (1.1)	153 (0.9)	0.03	1 (4.2)	17 (0.3)	0.27
Cardiopulmonary resuscitation - no. (%)	198 (0.6)	61 (0.3)	0.05	199 (0.5)	60 (0.4)	0.02	0 (0.0)	12 (0.2)	0.06
Atrial fibrillation - no. (%)	10471 (29.3)	6332 (26.7)	0.06	11619 (27.4)	5184 (30.5)	0.07	7 (29.2)	1518 (26.0)	0.07
Liver disease - no. (%)	2075 (5.8)	859 (3.6)	0.10	2320 (5.5)	614 (3.6)	0.09	2 (8.3)	195 (3.3)	0.21
Cancer - no. (%)	1479 (4.1)	637 (2.7)	0.08	1511 (3.6)	605 (3.6)	<0.001	2 (8.3)	143 (2.4)	0.26
Osteoporosis - no. (%)	1127 (3.2)	365 (1.5)	0.11	1166 (2.7)	326 (1.9)	0.06	1 (4.2)	75 (1.3)	0.18
Hip fracture - no. (%)	180 (0.5)	49 (0.2)	0.05	191 (0.4)	38 (0.2)	0.04	0 (0.0)	10 (0.2)	0.06
Malnutrition - no. (%)	1439 (4.0)	413 (1.7)	0.14	1563 (3.7)	289 (1.7)	0.12	0 (0.0)	90 (1.5)	0.18
Anemia - no. (%)	16912 (47.4)	10996 (46.3)	0.02	19395 (45.7)	8513 (50.1)	0.09	14 (58.3)	2798 (47.9)	0.21
Hypothyroidism - no. (%)	3686 (10.3)	1888 (8.0)	0.08	3994 (9.4)	1580 (9.3)	0.004	2 (8.3)	430 (7.4)	0.04
Asthma - no. (%)	2698 (7.6)	1381 (5.8)	0.07	2967 (7.0)	1112 (6.5)	0.02	2 (8.3)	355 (6.1)	0.09
Dementia - no. (%)	276 (0.8)	64 (0.3)	0.07	278 (0.7)	62 (0.4)	0.04	0 (0.0)	12 (0.2)	0.06
Immunosuppressed - no. (%)	927 (2.6)	391 (1.6)	0.07	919 (2.2)	399 (2.3)	0.01	1 (4.2)	89 (1.5)	0.16
Surgical status - no. (%)			0.25			0.18			1.63
Elective	11600 (32.5)	10041 (42.3)		14403 (33.9)	7238 (42.6)		20 (83.3)	2519 (43.1)	
Urgent	22286 (62.4)	13277 (55.9)		26335 (62.0)	9228 (54.3)		0 (0.0)	3213 (55.0)	
Emergent	1781 (5.0)	428 (1.8)		1693 (4.0)	516 (3.0)		3 (12.5)	110 (1.9)	
Emergent salvage	17 (0.0)	0 (0.0)		17 (0.0)	0 (0.0)		1 (4.2)	0 (0.0)	
Redo sternotomy - no. (%)	47 (0.1)	42 (0.2)	0.01	61 (0.1)	28 (0.2)	0.01	0 (0.0)	11 (0.2)	0.06
≥3 vessel disease - no. (%)	28714 (80.5)	19624 (82.7)	0.06	34486 (81.2)	13852 (81.6)	0.008	18 (75.0)	4826 (82.6)	0.19
Surgeon volume - isolated CABG cases	337 ± 181	326 ± 173	0.06	336 ± 181	323 ± 169	0.08	344 ± 199	321 ± 164	0.13

*Plus-minus valves are means +/- standard deviation. 4% of patients missing data for mitral regurgitation, otherwise no variable with >0.2% missingness. CABG, coronary artery bypass grafting; ITA, internal thoracic artery; PCI, percutaneous coronary intervention; SMD, standardized mean difference

Supplemental Table 4. Baseline Characteristics of the Study Population after Propensity Score Matching Stratified by Number of Diseased Vessels*

Characteristic	Two-Vessel Disease†			At-Least Three Vessel Disease†		
	Venous Second Conduit	Arterial Second Conduit		Venous Second Conduit	Arterial Second Conduit	
	(N=1,003)	(N=1,003)	SMD	(N=4,810)	(N=4,810)	SMD
Age - yr	62.4 ± 10.6	61.6 ± 10.7	0.08	62.5 ± 10.4	62.1 ± 10.4)	0.04
Year of surgery - yr	2008.1 ± 1.6	2008.1 ± 1.6	0.007	2008.1 ± 1.6	2008.1 ± 1.6	0.01
Male sex - no. (%)	798.5 (79.6)	821.0 (81.9)	0.06	4098.6 (85.2)	4139.0 (86.0)	0.02
Race - no. (%)			0.11			0.08
Unknown	13.3 (1.3)	13.0 (1.3)		62.8 (1.3)	53.0 (1.1)	
White	727.0 (72.5)	727.0 (72.5)		3434.0 (71.4)	3434.0 (71.4)	
Black	31.3 (3.1)	27.0 (2.7)		139.2 (2.9)	115.0 (2.4)	
Hispanic	105.0 (10.5)	105.0 (10.5)		550.0 (11.4)	550.0 (11.4)	
Asian	86.8 (8.6)	106.0 (10.6)		426.2 (8.9)	505.0 (10.5)	
Native American	1.6 (0.2)	2.0 (0.2)		9.6 (0.2)	9.0 (0.2)	
Other	38.0 (3.8)	23.0 (2.3)		188.2 (3.9)	144.0 (3.0)	
Height - cm	172.6 ± 10.1	173.0 ± 9.7	0.04	173.3 ± 9.6	173.4 ± 9.5	0.02
Weight - kg	87.6 ± 19.0	88.2 ± 19.7	0.03	88.1 ± 18.8	88.4 ± 18.4	0.01
Ejection fraction - %	57.7 ± 11.2	57.7 ± 11.2	0.001	55.2 ± 12.1	55.2 ± 12.1	<0.001
Creatinine - mg/dL	1.08 ± 0.65)	1.05 ± 0.49	0.06	1.09 ± 0.55	1.08 ± 0.55	0.01
Dialysis - no. (%)	7.4 (0.7)	4.0 (0.4)	0.05	48.8 (1.0)	43.0 (0.9)	0.01
Diabetes mellitus - no. (%)	321.2 (32.0)	306.0 (30.5)	0.03	1744.6 (36.3)	1745.0 (36.3)	<0.001
Hypertension - no. (%)	797.6 (79.5)	779.0 (77.7)	0.05	3950.8 (82.1)	3923.0 (81.6)	0.02
PVD - no. (%)	91.7 (9.1)	80.0 (8.0)	0.04	481.5 (10.0)	474.0 (9.9)	0.005
Cerebrovascular disease - no. (%)	93.4 (9.3)	84.0 (8.4)	0.03	465.2 (9.7)	443.0 (9.2)	0.02
Chronic lung disease - no. (%)			<0.001			<0.001
None	876.0 (87.3)	876.0 (87.3)		4081.0 (84.8)	4081.0 (84.8)	
Mild	78.0 (7.8)	78.0 (7.8)		501.0 (10.4)	501.0 (10.4)	
Moderate	34.0 (3.4)	34.0 (3.4)		144.0 (3.0)	144.0 (3.0)	
Severe	15.0 (1.5)	15.0 (1.5)		84.0 (1.7)	84.0 (1.7)	
Congestive heart failure - no. (%)	85.2 (8.5)	86.0 (8.6)	0.003	524.9 (10.9)	489.0 (10.2)	0.02
Prior MI - no. (%)			<0.001			<0.001
None	658 (65.6)	658 (65.6)		2668.0 (55.5)	2668.0 (55.5)	
>21 days	153.0 (15.3)	153.0 (15.3)		848.0 (17.6)	848.0 (17.6)	
8 to 21 days	23.0 (2.3)	23.0 (2.3)		117.0 (2.4)	117.0 (2.4)	
1 to 7 days	161.0 (16.1)	161.0 (16.1)		1089.0 (22.6)	1089.0 (22.6)	
>6 hrs but <24 hrs	6.0 (0.6)	6.0 (0.6)		58.0 (1.2)	58.0 (1.2)	
≤6 hrs	2.0 (0.2)	2.0 (0.2)		22.0 (0.5)	22.0 (0.5)	
Prior PCI - no. (%)			0.01			0.01
None	771.8 (77.0)	769.0 (76.7)		3891.8 (80.9)	3884.0 (80.7)	
>6 hrs	227.6 (22.7)	231.0 (23.0)		902.2 (18.8)	913.0 (19.0)	
≤6 hrs	3.6 (0.4)	3.0 (0.3)		15.9 (0.3)	13.0 (0.3)	
Mitral regurgitation - no. (%)			0.04			0.02
None	733.7 (73.1)	729.0 (72.7)		3206.6 (66.7)	3223.0 (67.0)	
Trivial	121.2 (12.1)	133.0 (13.3)		678.5 (14.1)	687.0 (14.3)	
Mild	91.9 (9.2)	89.0 (8.9)		589.2 (12.3)	565.0 (11.7)	
Moderate	18.4 (1.8)	17.0 (1.7)		151.2 (3.1)	140.0 (2.9)	
Severe	1.2 (0.1)	1.0 (0.1)		8.6 (0.2)	10.0 (0.2)	
Cardiogenic shock - no. (%)	3.5 (0.3)	2.0 (0.2)	0.03	18.8 (0.4)	13.0 (0.3)	0.02
CPR - no. (%)	2.8 (0.3)	2.0 (0.2)	0.02	10.2 (0.2)	8.0 (0.2)	0.01

Supplemental Table 4. Baseline Characteristics of the Study Population after Propensity Score Matching Stratified by Number of Diseased Vessels (continued)*

Characteristic	Two-Vessel Disease†			At-Least Three Vessel Disease†		
	Venous Second Conduit (N=1,003)	Arterial Second Conduit (N=1,003)	SMD	Venous Second Conduit (N=4,810)	Arterial Second Conduit (N=4,810)	SMD
Atrial fibrillation - no. (%)	256.4 (25.6)	252.0 (25.1)	0.01	1277.0 (26.5)	1261.0 (26.2)	0.008
Liver disease - no. (%)	34.1 (3.4)	30.0 (3.0)	0.02	164.8 (3.4)	165.0 (3.4)	<0.001
Cancer - no. (%)	35.6 (3.5)	32.0 (3.2)	0.02	112.6 (2.3)	112.0 (2.3)	0.001
Osteoporosis - no. (%)	18.0 (1.8)	14.0 (1.4)	0.03	68.3 (1.4)	62.0 (1.3)	0.01
Hip fracture - no. (%)	0.5 (0.0)	0.0 (0.0)	0.03	12.3 (0.3)	10.0 (0.2)	0.01
Malnutrition - no. (%)	15.2 (1.5)	11.0 (1.1)	0.04	85.1 (1.8)	79.0 (1.6)	0.01
Anemia - no. (%)	470.0 (46.9)	479.0 (47.8)	0.02	2292.0 (47.7)	2308.0 (48.0)	0.007
Hypothyroidism - no. (%)	81.3 (8.1)	76.0 (7.6)	0.02	368.6 (7.7)	355.0 (7.4)	0.01
Asthma - no. (%)	65.2 (6.5)	69.0 (6.9)	0.02	274.2 (5.7)	280.0 (5.8)	0.005
Dementia - no. (%)	5.4 (0.5)	3.0 (0.3)	0.04	12.0 (0.2)	9.0 (0.2)	0.01
Immunosuppressed - no. (%)	21.2 (2.1)	22.0 (2.2)	0.005	74.2 (1.5)	67.0 (1.4)	0.01
Surgical status - no. (%)						
Elective	465.0 (46.4)	465.0 (46.4)		2056.0 (42.7)	2056.0 (42.7)	
Urgent	523.0 (52.1)	523.0 (52.1)	<0.001	2670.0 (55.5)	2670.0 (55.5)	<0.001
Emergent	15.0 (1.5)	15.0 (1.5)		84.0 (1.7)	84.0 (1.7)	
Emergent salvage	0 (0)	0 (0)		0 (0)	0 (0)	
Redo sternotomy - no. (%)	3.1 (0.3)	3.0 (0.3)	0.002	8.3 (0.2)	8.0 (0.2)	0.002
≥3 vessel disease - no. (%)	0 (0)	0 (0)	-	4810.0 (100.0)	4810.0 (100.0)	-
Surgeon volume - isolated CABG	339 ± 175	308 ± 167	0.18	322 ± 174	325 ± 163	0.01

*Plus-minus valves are means +/- standard deviation. 4% of patients missing data for mitral regurgitation, otherwise no variable with >0.2% missingness. If any missing data present, groups were balanced on missingness for each variable. CABG, coronary artery bypass grafting; CPR, cardiopulmonary resuscitation; MI, myocardial infarction; PCI, percutaneous coronary intervention; PVD, peripheral vascular disease; SMD, standardized mean difference

†The number of patients and proportions presented are weighted due to variable 1:k matching and for estimation of the average treatment effect on the treated. Total number matched: 2-vessel arterial conduit = 1,003, 2-vessel venous conduit = 3,116; 3-vessel arterial conduit = 4,810, 3-vessel venous conduit = 14,814

Supplemental Table 5. Baseline Characteristics of the Study Population Before and After Near-Far Matching*

	Before Matching			After Matching		
	Unencouraged	Encouraged		Unencouraged	Encouraged	
Characteristic	(N=50,708)	(N=8,724)	SMD	(N=8,491)	(N=8,491)	SMD
Age - yr	66.0 ± 10.5	66.2 ± 10.7	0.02	66.0 ± 10.3	66.2 ± 10.7	0.02
Year of surgery - yr	2008.2 ± 1.6	2008.1 ± 1.6	0.01	2008.1 ± 1.6	2008.1 ± 1.6	0.02
Male sex - no. (%)	38190 (75.3)	6743 (77.3)	0.05	6615 (77.9)	6582 (77.5)	0.009
Race - no. (%)			0.32			0.08
Unknown	819 (1.6)	106 (1.2)		130 (1.5)	105 (1.2)	
White	30144 (59.4)	6374 (73.1)		6205 (73.1)	6205 (73.1)	
Black	1994 (3.9)	277 (3.2)		270 (3.2)	270 (3.2)	
Hispanic	9544 (18.8)	917 (10.5)		881 (10.4)	881 (10.4)	
Asian	5804 (11.4)	837 (9.6)		710 (8.4)	821 (9.7)	
Native American	103 (0.2)	23 (0.3)		17 (0.2)	22 (0.3)	
Other	2300 (4.5)	190 (2.2)		278 (3.3)	187 (2.2)	
Height - cm	170.3 ± 10.5	171.8 ± 10.1	0.14	171.8 ± 10.2	171.8 ± 10.1	0.004
Weight - kg	84.0 ± 18.9	85.4 ± 18.7	0.07	85.6 ± 18.8	85.4 ± 18.7	0.01
Ejection fraction - %	52.4 ± 13.5	54.8 ± 13.2	0.18	54.7 ± 13.0	54.8 ± 13.1	0.005
Creatinine - mg/dL	1.26 ± 1.10	1.23 ± 1.00	0.03	1.24 ± 1.04	1.23 ± 1.00	0.008
Dialysis - no. (%)	1941 (3.8)	303 (3.5)	0.02	309 (3.6)	295 (3.5)	0.009
Diabetes mellitus - no. (%)	22996 (45.3)	3562 (40.8)	0.09	3460 (40.7)	3454 (40.7)	0.001
Hypertension - no. (%)	43811 (86.4)	7347 (84.2)	0.06	7169 (84.4)	7144 (84.1)	0.008
PVD - no. (%)	6879 (13.6)	1063 (12.2)	0.04	966 (11.4)	1030 (12.1)	0.02
Cerebrovascular disease - no. (%)	6904 (13.6)	1075 (12.3)	0.04	1036 (12.2)	1047 (12.3)	0.004
Chronic lung disease - no. (%)			0.14			<0.001
None	39850 (78.6)	7244 (83.0)		7139 (84.1)	7139 (84.1)	
Mild	5983 (11.8)	955 (10.9)		883 (10.4)	883 (10.4)	
Moderate	2806 (5.5)	315 (3.6)		284 (3.3)	284 (3.3)	
Severe	2041 (4.0)	210 (2.4)		185 (2.2)	185 (2.2)	
Congestive heart failure - no. (%)	9323 (18.4)	1249 (14.3)	0.11	1183 (13.9)	1199 (14.1)	0.02
Prior MI - no. (%)			0.10			<0.001
None	25957 (51.2)	4599 (52.7)		4577 (53.9)	4577 (53.9)	
>21 days	8706 (17.2)	1554 (17.8)		1499 (17.7)	1499 (17.7)	
8 to 21 days	2376 (4.7)	297 (3.4)		266 (3.1)	266 (3.1)	
1 to 7 days	11723 (23.1)	1972 (22.6)		1926 (22.7)	1926 (22.7)	
>6 hrs but <24 hrs	1292 (2.6)	175 (2.0)		143 (1.7)	143 (1.7)	
≤6 hrs	564 (1.1)	126 (1.4)		80 (0.9)	80 (0.9)	
Prior PCI - no. (%)			0.03			0.03
None	39817 (78.5)	6875 (78.8)		6621 (78.0)	6721 (79.2)	
>6 hrs	10538 (20.8)	1770 (20.3)		1803 (21.2)	1708 (20.1)	
≤6 hrs	350 (0.7)	79 (0.9)		67 (0.8)	62 (0.7)	
Mitral regurgitation - no. (%)			0.16			0.02
None	33929 (66.9)	5425 (62.2)		5277 (62.1)	5275 (62.1)	
Trivial	5479 (10.8)	1355 (15.5)		1271 (15.0)	1323 (15.6)	
Mild	6805 (13.4)	1237 (14.2)		1246 (14.7)	1208 (14.2)	
Moderate	2162 (4.3)	411 (4.7)		400 (4.7)	397 (4.7)	
Severe	213 (0.4)	33 (0.4)		33 (0.4)	31 (0.4)	
Cardiogenic shock - no. (%)	533 (1.1)	101 (1.2)	0.01	75 (0.9)	78 (0.9)	0.004
CPR - no. (%)	224 (0.4)	35 (0.4)	0.009	34 (0.4)	26 (0.3)	0.02
Atrial fibrillation - no. (%)	14119 (27.8)	2684 (30.8)	0.06	2574 (30.3)	2610 (30.7)	0.009
Liver disease - no. (%)	2622 (5.2)	312 (3.6)	0.08	314 (3.7)	300 (3.5)	0.009

Supplemental Table 5. Baseline Characteristics of the Study Population Before and After Near-Far Matching (continued)*

	Before Matching			After Matching		
	Unencouraged	Encouraged		Unencouraged	Encouraged	
Characteristic	**(N=50,708)**	**(N=8,724)**	**SMD**	**(N=8,491)**	**(N=8,491)**	**SMD**
Cancer - no. (%)	1803 (3.6)	313 (3.6)	0.002	305 (3.6)	300 (3.5)	0.003
Osteoporosis - no. (%)	1309 (2.6)	183 (2.1)	0.03	153 (1.8)	173 (2.0)	0.02
Hip fracture - no. (%)	205 (0.4)	24 (0.3)	0.02	15 (0.2)	23 (0.3)	0.02
Malnutrition - no. (%)	1701 (3.4)	151 (1.7)	0.10	145 (1.7)	144 (1.7)	0.001
Anemia - no. (%)	23458 (46.3)	4450 (51.0)	0.10	4169 (49.1)	4344 (51.2)	0.04
Hypothyroidism - no. (%)	4737 (9.3)	837 (9.6)	0.009	768 (9.0)	812 (9.6)	0.02
Asthma - no. (%)	3484 (6.9)	595 (6.8)	0.002	546 (6.4)	566 (6.7)	0.01
Dementia - no. (%)	306 (0.6)	34 (0.4)	0.03	29 (0.3)	33 (0.4)	0.008
Immunosuppressed - no. (%)	1104 (2.2)	214 (2.5)	0.02	196 (2.3)	203 (2.4)	0.02
Surgical status - no. (%)						
Elective	17959 (35.4)	3682 (42.2)		3619 (42.6)	3619 (42.6)	
Urgent	30882 (60.9)	4681 (53.7)	0.15	4614 (54.3)	4614 (54.3)	<0.001
Emergent	1854 (3.7)	355 (4.1)		258 (3.0)	258 (3.0)	
Emergent salvage	11 (0.0)	6 (0.1)		0 (0)	0 (0)	
Redo sternotomy - no. (%)	71 (0.1)	18 (0.2)	0.02	11 (0.1)	17 (0.2)	0.02
≥3 vessel disease - no. (%)	41268 (81.4)	7070 (81.0)	0.009	6926 (81.6)	6926 (81.6)	<0.001
Surgeon volume - isolated CABG cases	336 ± 182	312 ± 153	0.14	333 ± 183	312 ± 153	0.12
Surgeon use of second arterial conduits - %	4.0 ± 5.0	44.0 ± 19.0	2.92	1.0 ± 1.0	44.0 ± 19.0	3.20

*Plus-minus valves are means +/- standard deviation. 4% of patients missing data for mitral regurgitation, otherwise no variable with >0.2% missingness. If any missing data present, groups were balanced on missingness for each variable. CABG, coronary artery bypass grafting; CPR, cardiopulmonary resuscitation; MI, myocardial infarction; PCI, percutaneous coronary intervention; PVD, peripheral vascular disease; SMD, standardized mean difference

Supplemental Table 6. Baseline Characteristics of the Study Population Before and After Propensity Score Matching for Comparison of Right Internal Thoracic Artery vs. Radial Artery Conduits*

	Before Matching			After Matching†		
Characteristic	Radial Artery (N=4,290)	Right ITA (N=1,576)	SMD	Radial Artery (N=4,272.5)	Right ITA (N=1,569.6)	SMD
Age - yr	62.5 ± 10.4	60.8 ± 10.5	0.16	62.1 ± 10.5	61.7 ± 10.3	0.04
Year of surgery - yr	2008.1 ± 1.6	2008.1 ± 1.6	<0.001	2008.1 ± 1.6	2008.1 ± 1.6	0.002
Male sex - no. (%)	3659 (85.3)	1344 (85.3)	<0.001	3654.0 (85.5)	1345.5 (85.7)	0.006
Race - no. (%)			0.18			0.05
Unknown	57 (1.3)	9 (0.6)		49.3 (1.2)	13.2 (0.8)	
White	3051 (71.1)	1139 (72.3)		3063.6 (71.7)	1125.4 (71.7)	
Black	122 (2.8)	24 (1.5)		90.0 (2.1)	33.0 (2.1)	
Hispanic	492 (11.5)	173 (11.0)		486.3 (11.4)	178.7 (11.4)	
Asian	461 (10.7)	157 (10.0)		458.5 (10.7)	162.3 (10.3)	
Native American	10 (0.2)	2 (0.1)		9.8 (0.2)	3.2 (0.2)	
Other	97 (2.3)	72 (4.6)		115.1 (2.7)	53.7 (3.4)	
Height - cm	173.2 ± 9.5	173.7 ± 9.6	0.06	173.3 ± 9.5	173.4 ± 9.6	0.01
Weight - kg	89.2 ± 19.1	85.6 ± 17.0	0.20	88.4 ± 18.7	87.4 ± 17.5	0.05
Ejection fraction - %	55.5 ± 12.0	56.0 ± 12.1	0.05	55.5 ± 12.0	56.1 ± 12.0	0.05
Creatinine - mg/dL	1.06 ± 0.41	1.12 ± 0.80	0.10	1.06 ± 0.43	1.10 ± 0.69	0.06
Dialysis - no. (%)	25 (0.6)	23 (1.5)	0.09	27.5 (0.6)	12.9 (0.8)	0.02
Diabetes mellitus - no. (%)	1681 (39.2)	396 (25.1)	0.30	1525.1 (35.7)	528.2 (33.7)	0.04
Hypertension - no. (%)	3528 (82.2)	1216 (77.2)	0.13	3454.6 (80.9)	1249.0 (79.6)	0.03
PVD - no. (%)	376 (8.8)	182 (11.5)	0.09	401.9 (9.4)	143.7 (9.2)	0.009
Cerebrovascular disease - no. (%)	379 (8.8)	152 (9.6)	0.03	383.9 (9.0)	149.4 (9.5)	0.02
Chronic lung disease - no. (%)			0.21			0.05
None	3717 (86.6)	1266 (80.3)		3639.2 (85.2)	1324.3 (84.4)	
Mild	414 (9.7)	178 (11.3)		439.4 (10.3)	160.9 (10.3)	
Moderate	104 (2.4)	81 (5.1)		125.4 (2.9)	52.4 (3.3)	
Severe	55 (1.3)	49 (3.1)		68.5 (1.6)	30.9 (2.0)	
Congestive heart failure - no. (%)	408 (9.5)	175 (11.1)	0.05	416.0 (9.7)	158.0 (10.1)	0.01
Prior MI - no. (%)			0.21			0.05
None	2360 (55.0)	972 (61.7)		2424.8 (56.8)	909.4 (57.9)	
>21 days	749 (17.5)	261 (16.6)		735.4 (17.2)	259.8 (16.6)	
8 to 21 days	100 (2.3)	43 (2.7)		104.5 (2.4)	45.7 (2.9)	
1 to 7 days	999 (23.3)	258 (16.4)		922.5 (21.6)	319.4 (20.4)	
>6 hrs but <24 hrs	41 (0.9)	29 (1.8)		45.4 (1.0)	20.7 (1.3)	
≤6 hrs	26 (0.6)	10 (0.6)		26.8 (0.6)	10.2 (0.7)	
Prior PCI - no. (%)			0.03			0.02
None	3420 (79.7)	1271 (80.6)		3419.5 (80.0)	1268.4 (80.8)	
>6 hrs	856 (20.0)	298 (18.9)		837.1 (19.6)	296.1 (18.9)	
≤6 hrs	14 (0.3)	7 (0.4)		15.9 (0.4)	5.1 (0.3)	
Mitral regurgitation - no. (%)			0.11			0.03
None	2899 (67.6)	1088 (69.0)		2898.1 (67.8)	1061.8 (67.6)	
Trivial	628 (14.6)	200 (12.7)		612.0 (14.3)	216.8 (13.8)	
Mild	499 (11.6)	161 (10.2)		482.9 (11.3)	179.2 (11.4)	
Moderate	114 (2.7)	45 (2.9)		114.9 (2.7)	49.7 (3.2)	
Severe	8 (0.2)	3 (0.2)		8.0 (0.2)	3.0 (0.2)	
Cardiogenic shock - no. (%)	11 (0.3)	7 (0.4)	0.03	12.6 (0.3)	5.4 (0.3)	0.009
CPR - no. (%)	10 (0.2)	2 (0.1)	0.03	8.7 (0.2)	1.1 (0.1)	0.04

Supplemental Table 6. Baseline Characteristics of the Study Population Before and After Propensity Score Matching for Comparison of Right Internal Thoracic Artery vs. Radial Artery Conduits (continued)*

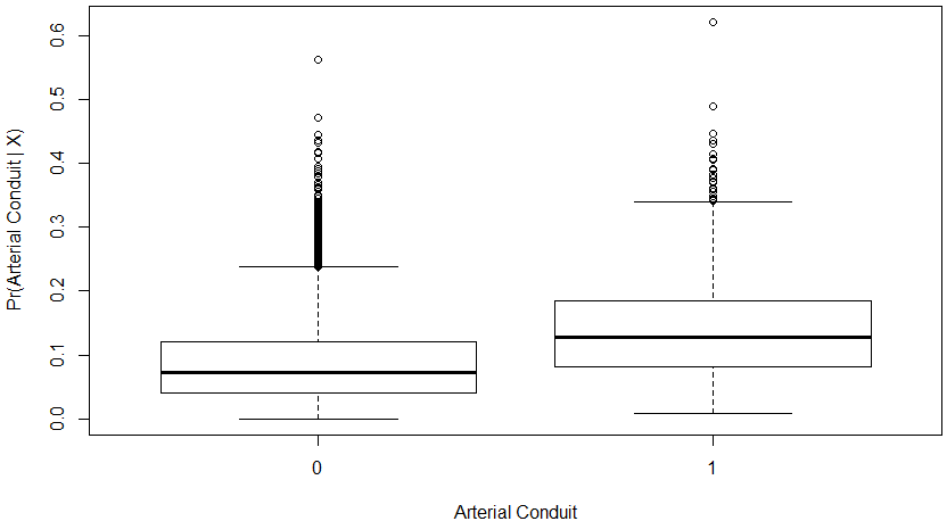
	Before Matching			After Matching†		
Characteristic	**Radial Artery (N=4,290)**	**Right ITA (N=1,576)**	**SMD**	**Radial Artery (N=4,272.5)**	**Right ITA (N=1,569.6)**	**SMD**
Atrial fibrillation - no. (%)	1149 (26.8)	376 (23.9)	0.07	1112.6 (26.0)	386.3 (24.6)	0.03
Liver disease - no. (%)	141 (3.3)	56 (3.6)	0.02	139.3 (3.3)	51.9 (3.3)	0.002
Cancer - no. (%)	110 (2.6)	35 (2.2)	0.02	106.3 (2.5)	37.6 (2.4)	0.006
Osteoporosis - no. (%)	57 (1.3)	19 (1.2)	0.01	55.1 (1.3)	21.5 (1.4)	0.007
Hip fracture - no. (%)	7 (0.2)	3 (0.2)	0.006	6.6 (0.2)	3.0 (0.2)	0.008
Malnutrition - no. (%)	48 (1.1)	42 (2.7)	0.11	57.8 (1.4)	30.9 (2.0)	0.05
Anemia - no. (%)	2175 (50.7)	637 (40.4)	0.21	2039.6 (47.7)	726.7 (46.3)	0.03
Hypothyroidism - no. (%)	312 (7.3)	120 (7.6)	0.01	314.6 (7.4)	103.4 (6.6)	0.03
Asthma - no. (%)	271 (6.3)	86 (5.5)	0.04	262.1 (6.1)	88.1 (5.6)	0.02
Dementia - no. (%)	8 (0.2)	4 (0.3)	0.01	9.0 (0.2)	3.8 (0.2)	0.006
Immunosuppressed - no. (%)	63 (1.5)	27 (1.7)	0.02	65.4 (1.5)	21.5 (1.4)	0.01
Surgical status - no. (%)						
Elective	1794 (41.8)	745 (47.3)		1842.2 (43.1)	676.8 (43.1)	
Urgent	2428 (56.6)	785 (49.8)	0.16	2349.8 (55.0)	863.2 (55.0)	<0.001
Emergent	67 (1.6)	46 (2.9)		80.4 (1.9)	29.6 (1.9)	
Emergent salvage	1 (0.0)	0 (0.0)		0 (0)	0 (0)	
Redo sternotomy - no. (%)	7 (0.2)	4 (0.3)	0.02	7.3 (0.2)	2.1 (0.1)	0.008
≥3 vessel disease - no. (%)	3547 (82.7)	1297 (82.3)	0.01	3520.7 (82.4)	1308.1 (83.3)	0.03
Surgeon volume - isolated CABG cases	328 ± 161	305 ± 171	0.13	322 ± 161	317 ± 172	0.03

*Plus-minus valves are means +/- standard deviation. 4% of patients missing data for mitral regurgitation, otherwise no variable with >0.2% missingness. If any missing data present, groups were balanced on missingness for each variable. CABG, coronary artery bypass grafting; CPR, cardiopulmonary resuscitation; ITA, internal thoracic artery; MI, myocardial infarction; PCI, percutaneous coronary intervention; PVD, peripheral vascular disease; SMD, standardized mean difference

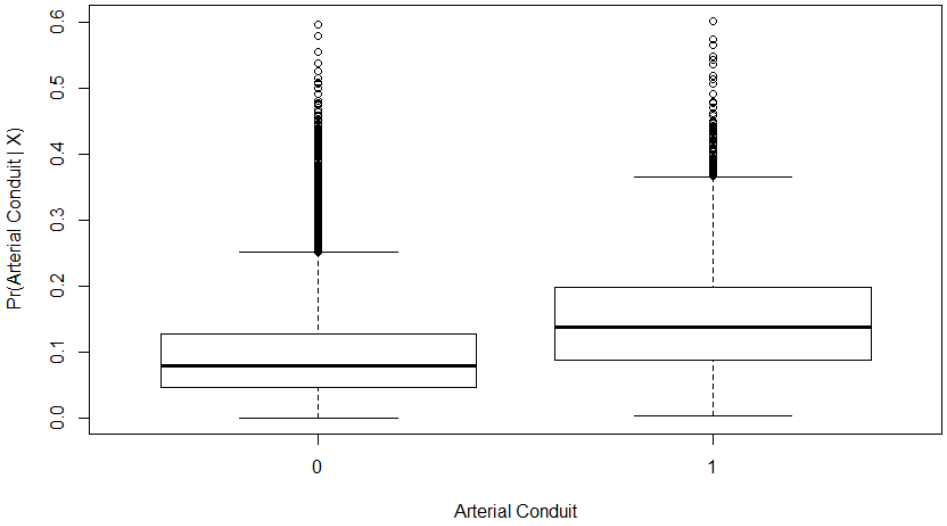
†The number of patients and proportions presented are weighted due to variable 1:k matching and for estimation of the average treatment effect. Total number matched: radial artery = 4,268; right internal thoracic artery = 1,574; 24 of 5,866 (0.4%) patients unmatched

Supplemental Figure 1. Distribution of Propensity Scores, Stratified by Number of Diseased Vessels and Comparison of Interest

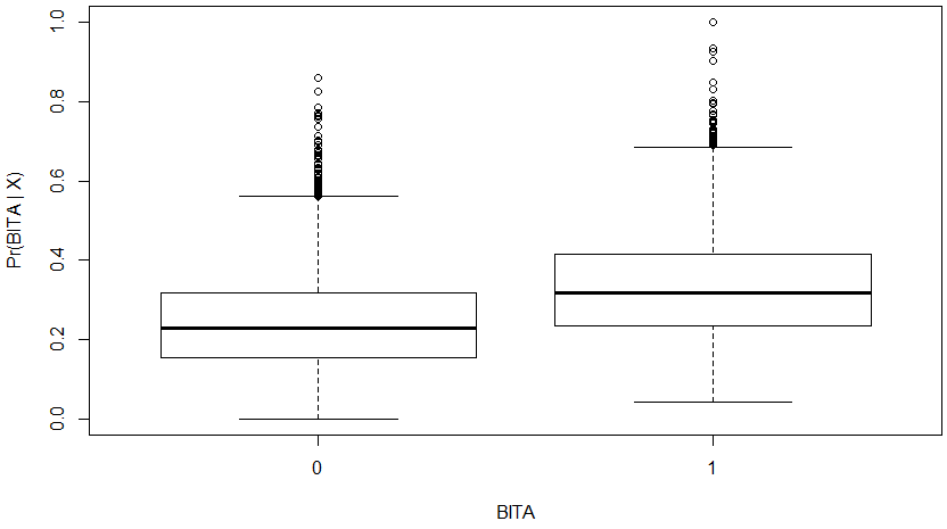
A Two-vessel disease: second arterial vs. venous conduit



B Three-or-more vessel disease: second arterial vs. venous conduit



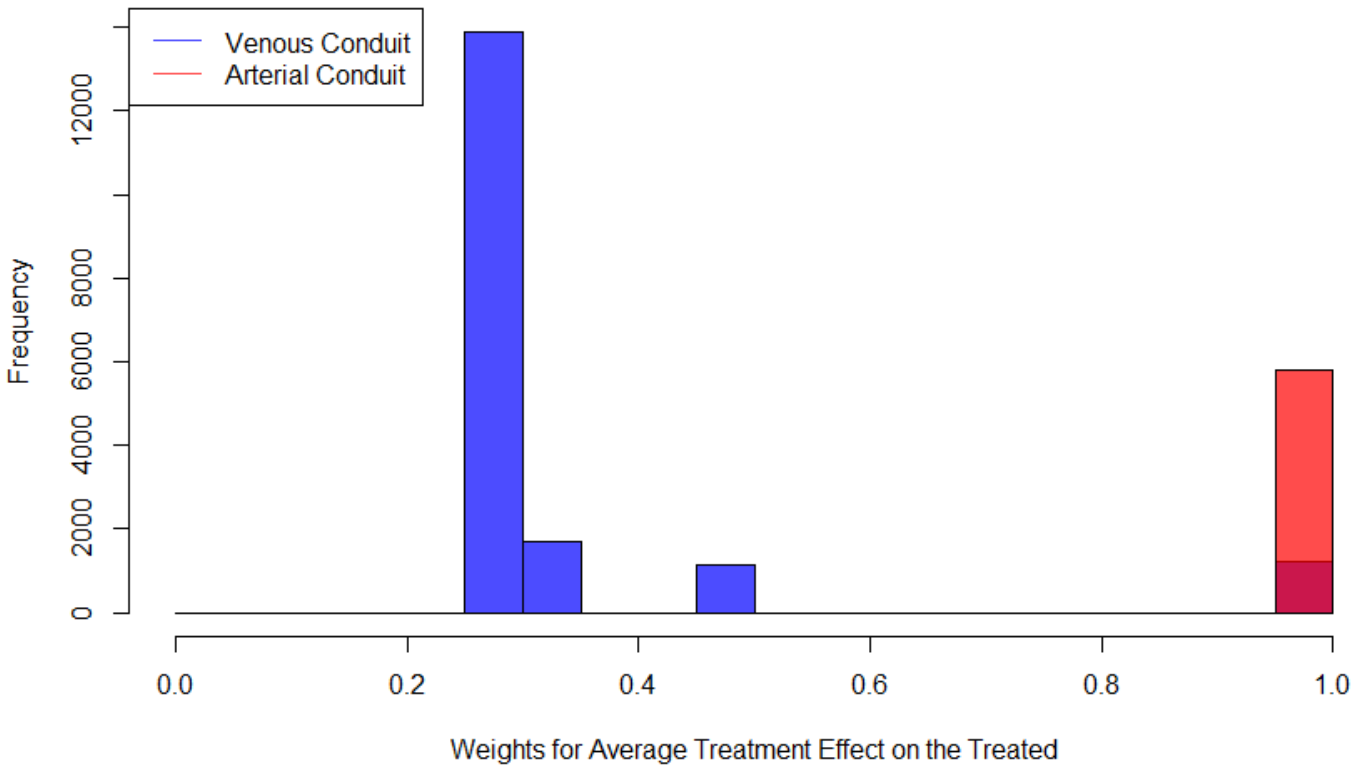
C Right internal thoracic artery vs. radial artery



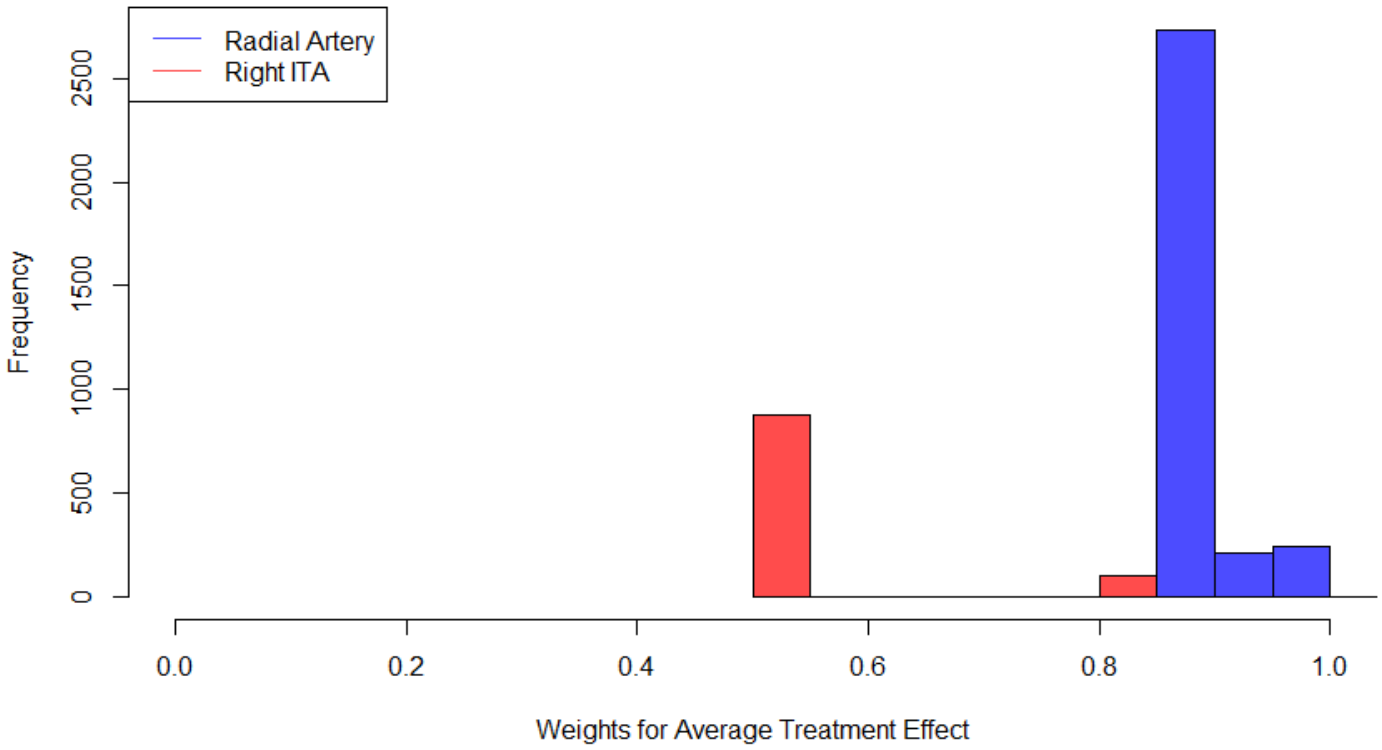
0=No, 1=Yes; BITA, bilateral internal thoracic artery grafts

Supplemental Figure 2. Distribution of Weights for Comparison of Second Arterial Conduit vs. Venous Conduit and for Right Internal Thoracic Artery Conduit vs. Radial Artery Conduit*

A Second arterial vs. venous conduit†



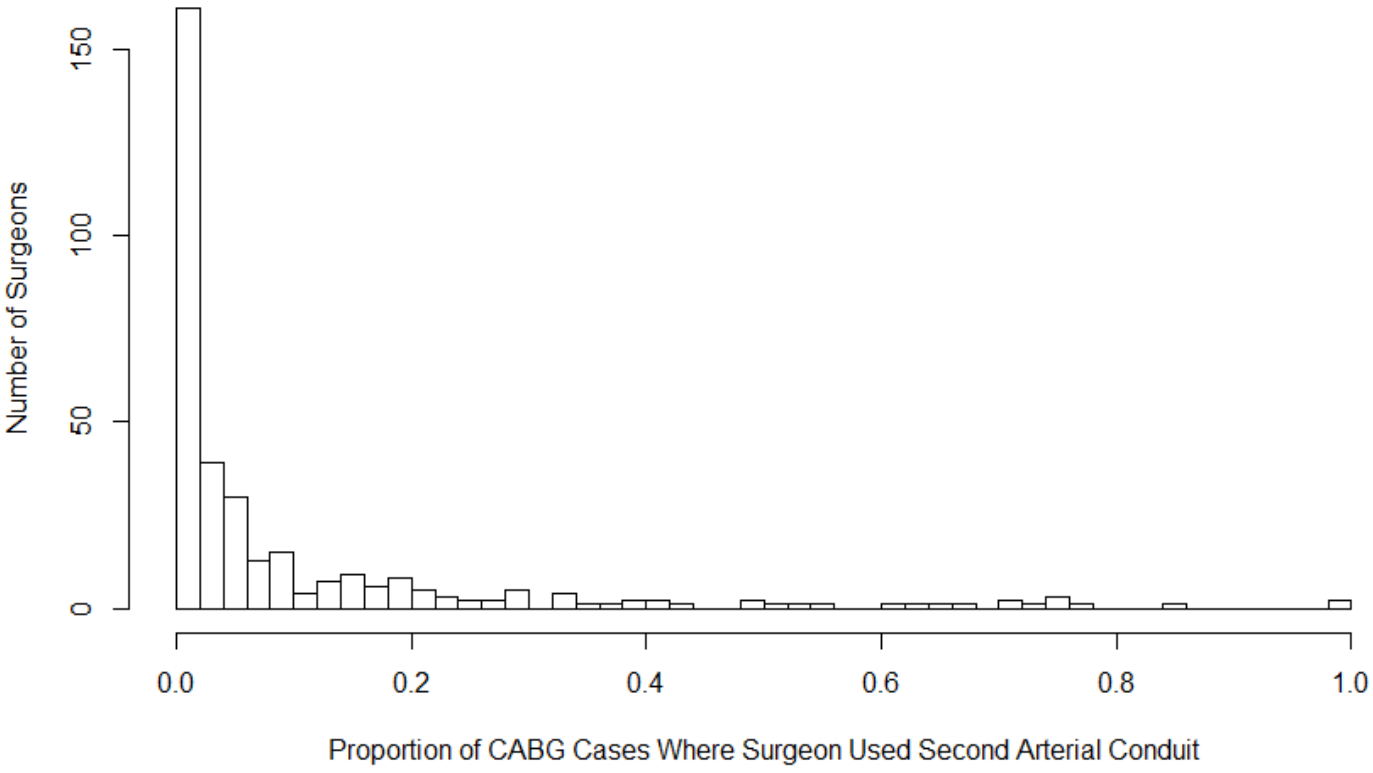
B Right internal thoracic artery vs. radial artery conduit



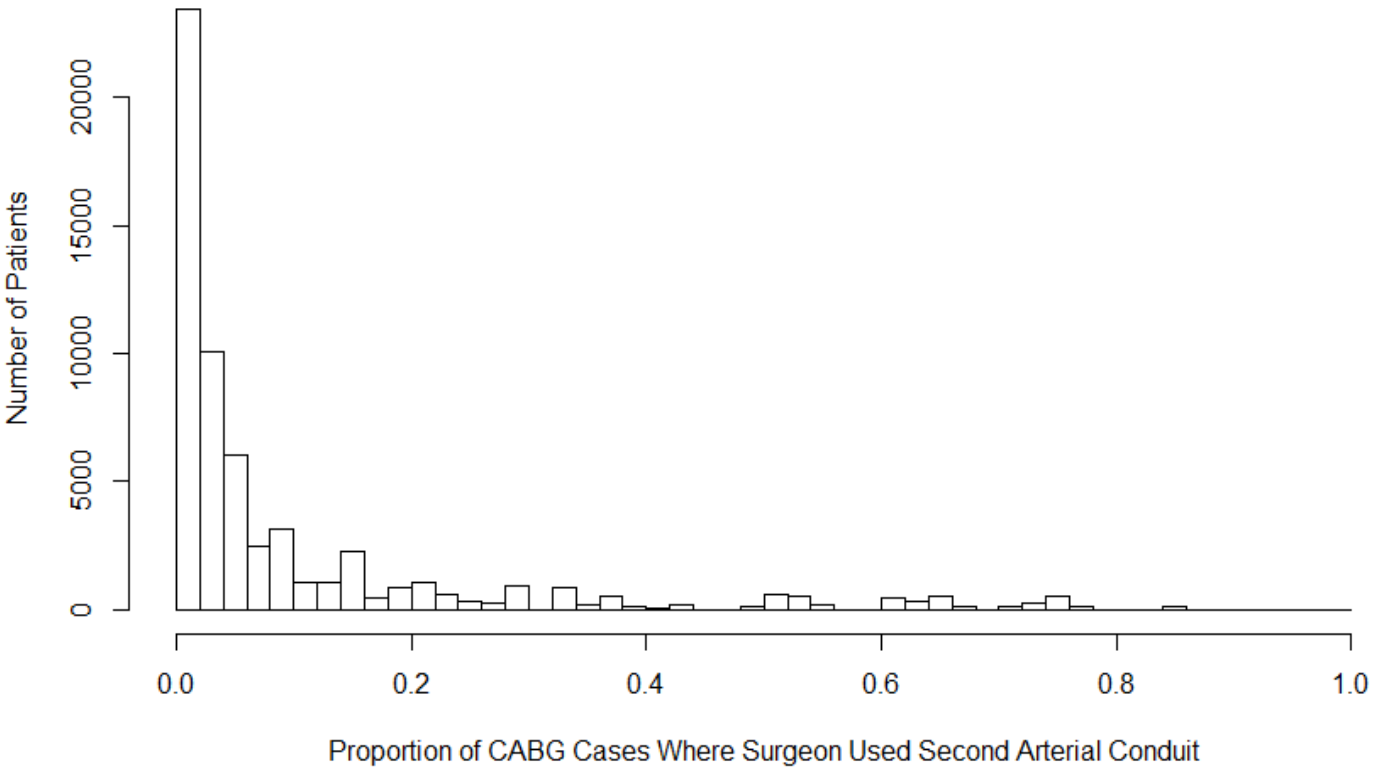
*Dark red represents part of bin that is overlapping between groups.
†All weights for patients in the second arterial conduit group (treated) received a weight of 1 to estimate the average treatment effect on the treated.
ITA, internal thoracic artery

Supplemental Figure 3. Distribution of Surgeon Utilization of Second Arterial Conduits and of Patients Presenting to Surgeons who Use Second Arterial Conduits at Varying Rates

A Surgeon utilization of second arterial conduits

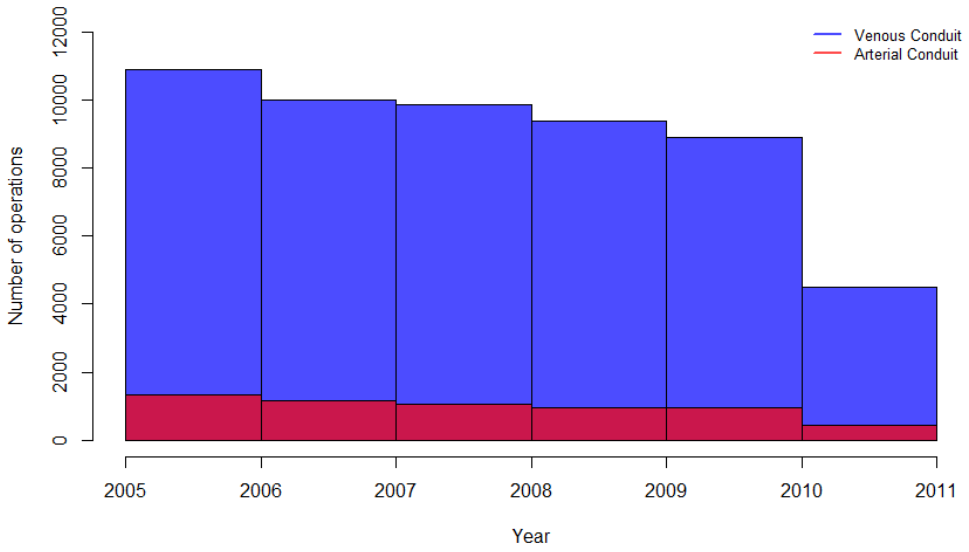


B Patients who presented to surgeons of varying rates of second arterial conduit use

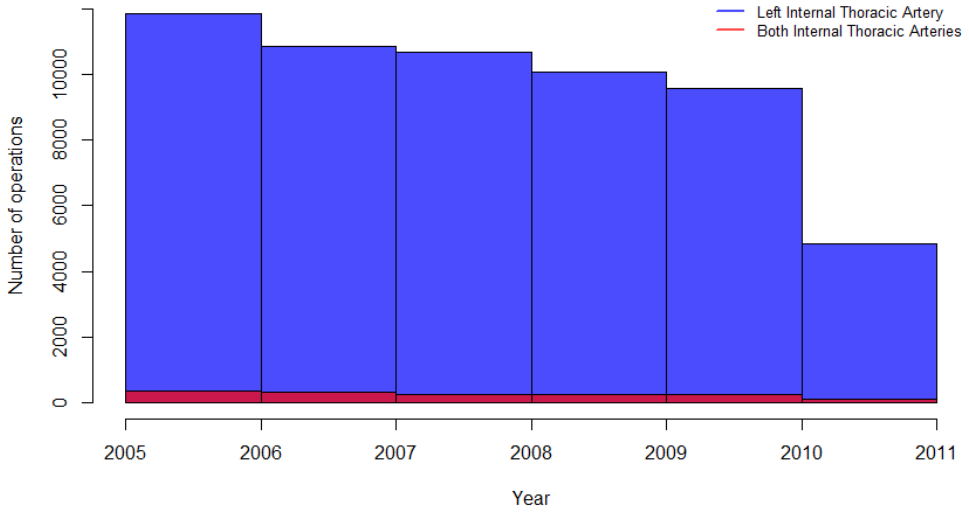


Supplemental Figure 4. Use of Second Arterial Conduits During the Study Period*

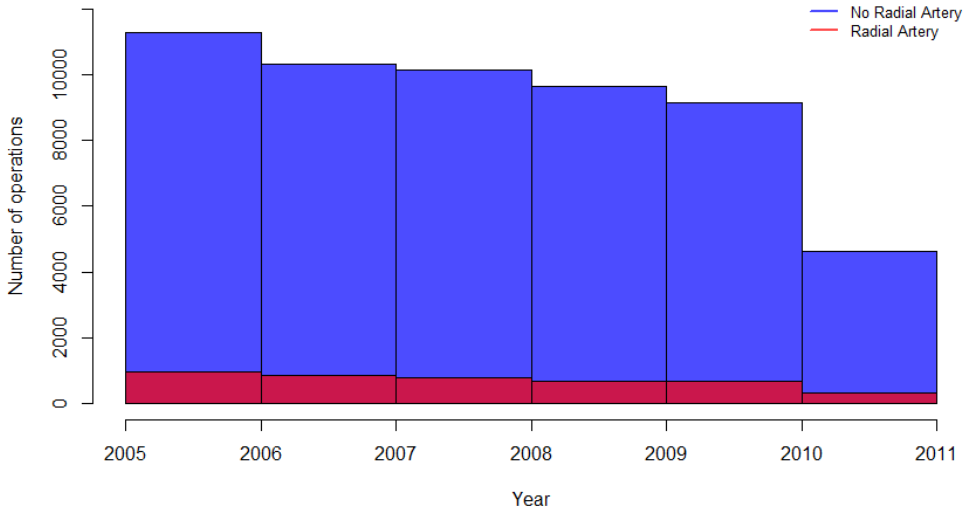
A Second arterial conduit vs. venous conduit



B Bilateral internal thoracic arteries vs. left internal thoracic artery

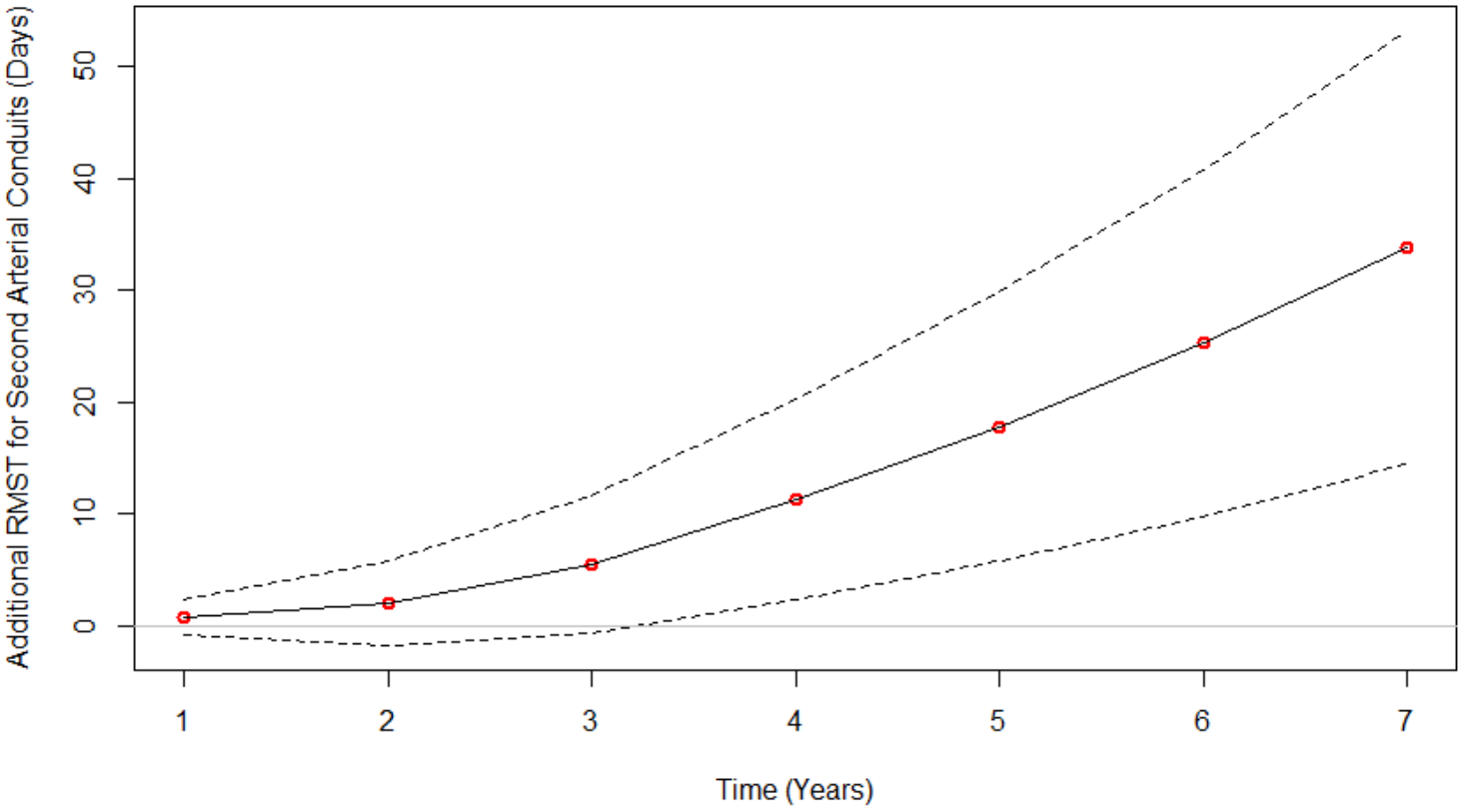


C Radial artery vs. no radial artery



*Data for 2011 is truncated at July 1, 2011 (the last date of study entry).

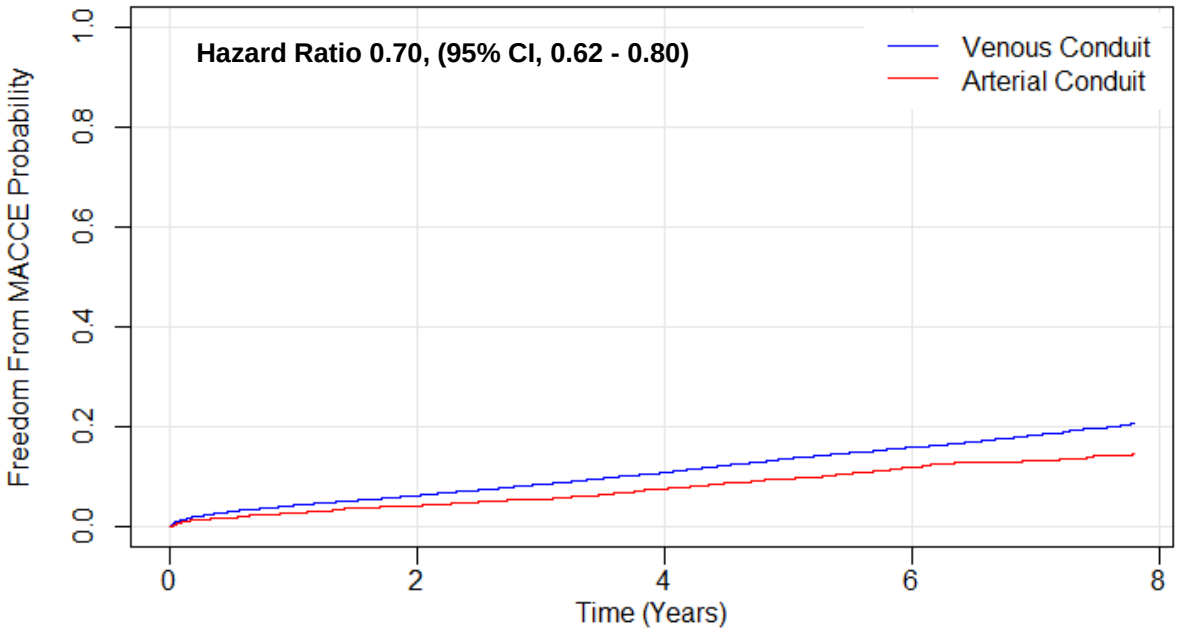
Supplemental Figure 5. Net Survival Penalty or Benefit of Second Arterial Conduits Over Time (Additional Area Under the Survival Curve)



Red circles represent point estimates of the difference in restricted mean survival time between recipients of second arterial conduits vs. venous conduits each year after surgery. Dashed lines are 95% confidence intervals.

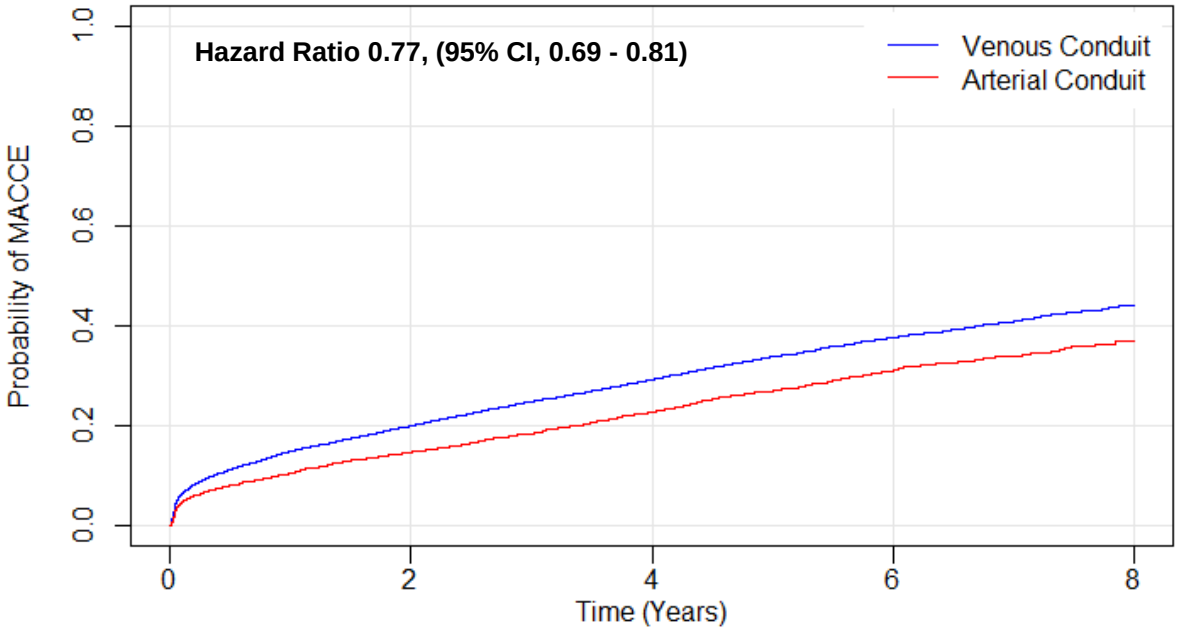
Supplemental Figure 6. Mortality and Major Adverse Cardiovascular and Cerebrovascular Events after Coronary Artery Bypass Surgery - Instrumental Variable Analysis

A Mortality



Venous Conduit	13096	12206	8726	4090	27
Arterial Conduit	3886	3756	2836	1514	8

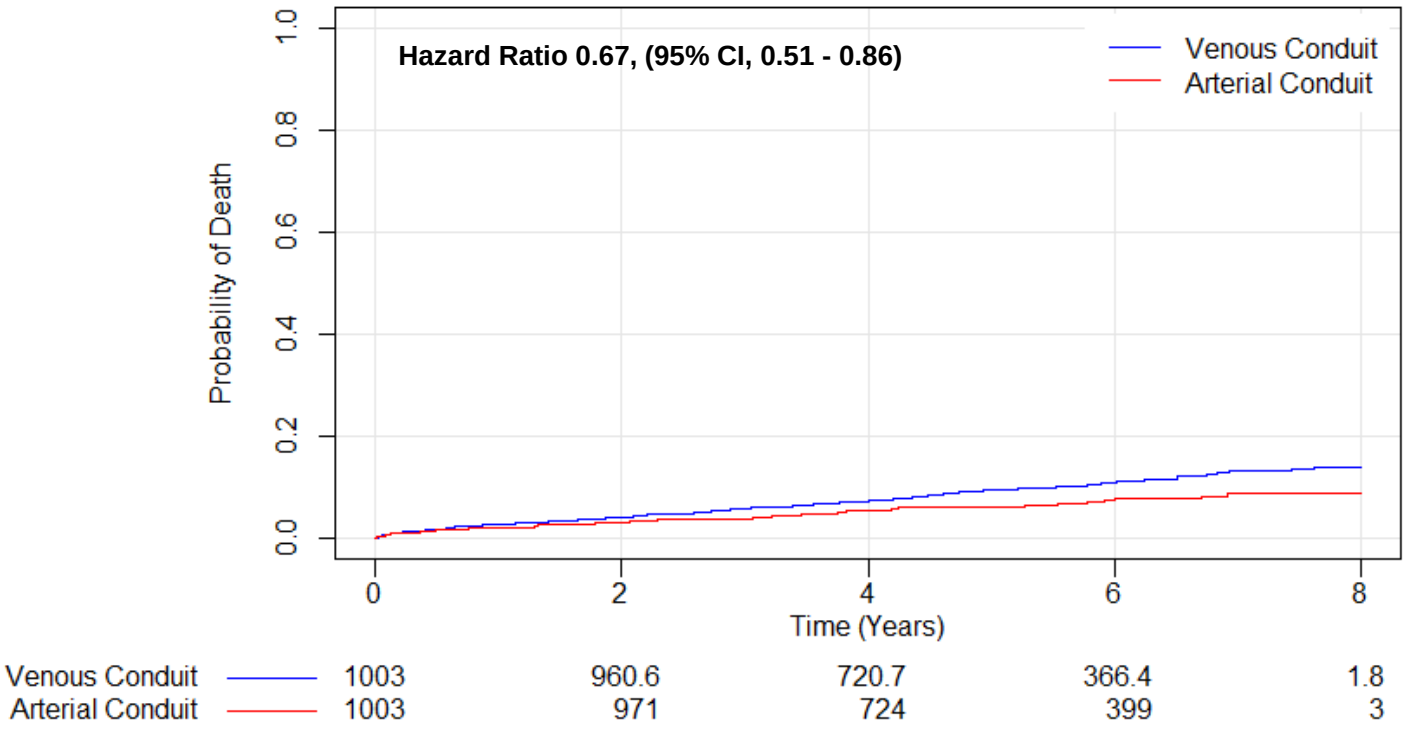
B MACCE



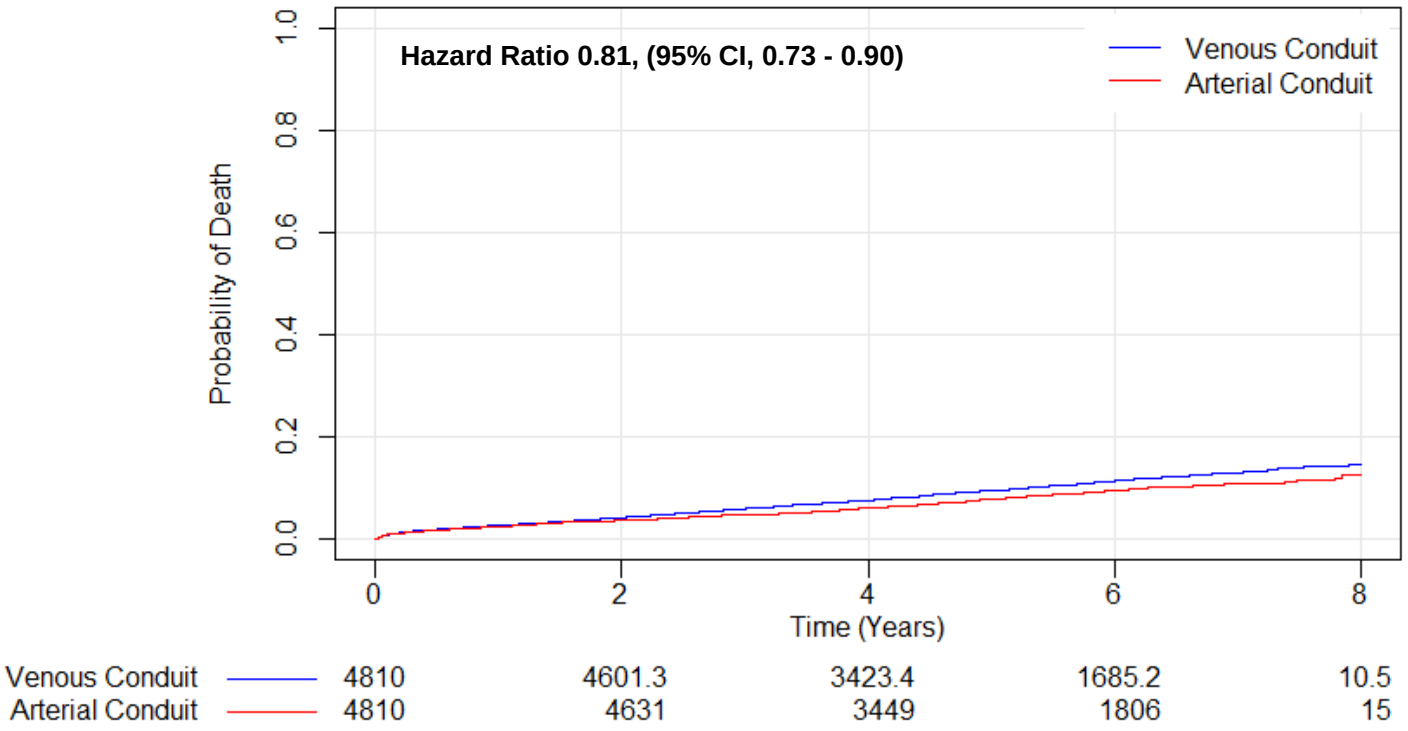
Venous Conduit	13096	10368	6922	3070	19
Arterial Conduit	3886	3381	2410	1215	6

Supplemental Figure 7. Mortality after Coronary Artery Bypass Surgery with a Second Arterial vs. Venous Conduit Stratified by Number of Diseased Vessels

A Two-vessel disease

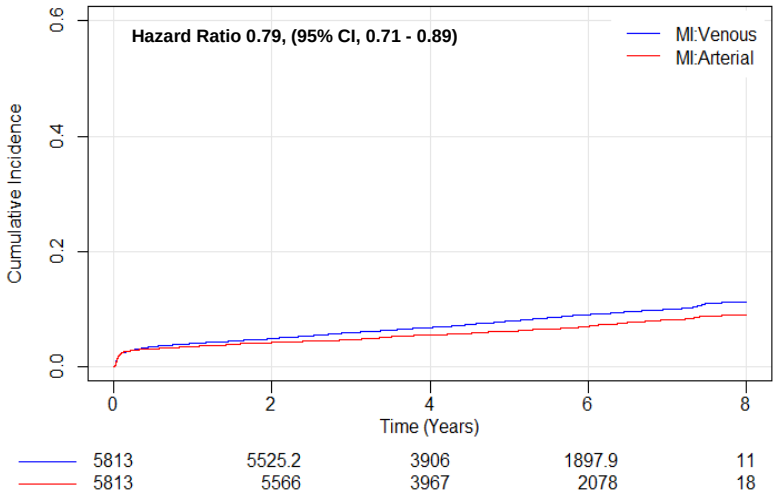


B Three-or-more vessel disease



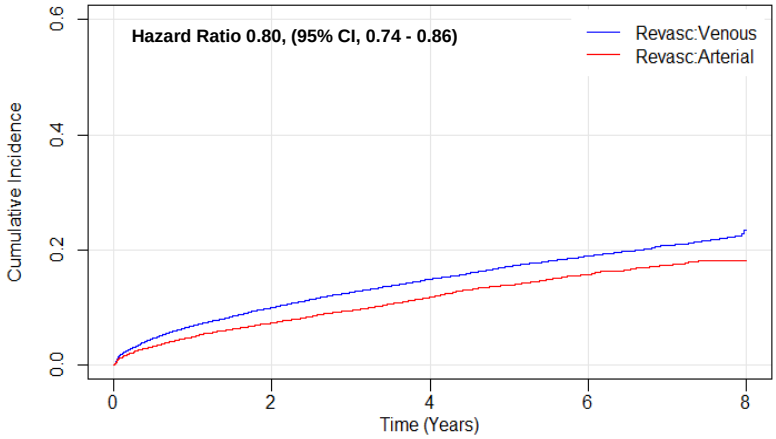
Supplemental Figure 8. Competing Risks of Myocardial Infarction, Repeat Revascularization, or Stroke with Death, Stratified by Second Conduit Type

A Myocardial infarction



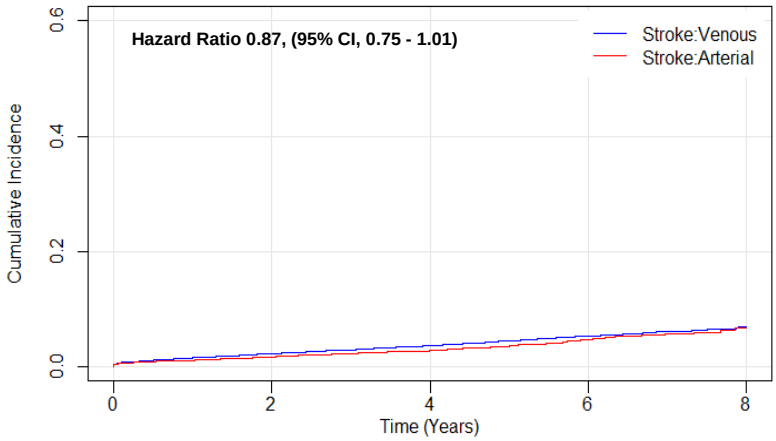
MI:Venous	5813	5525.2	3906	1897.9	11
MI:Arterial	5813	5566	3967	2078	18

B Repeat revascularization



Revasc:Venous	5813	5231.3	3568.9	1695.1	7.5
Revasc:Arterial	5813	5387	3714	1879	14

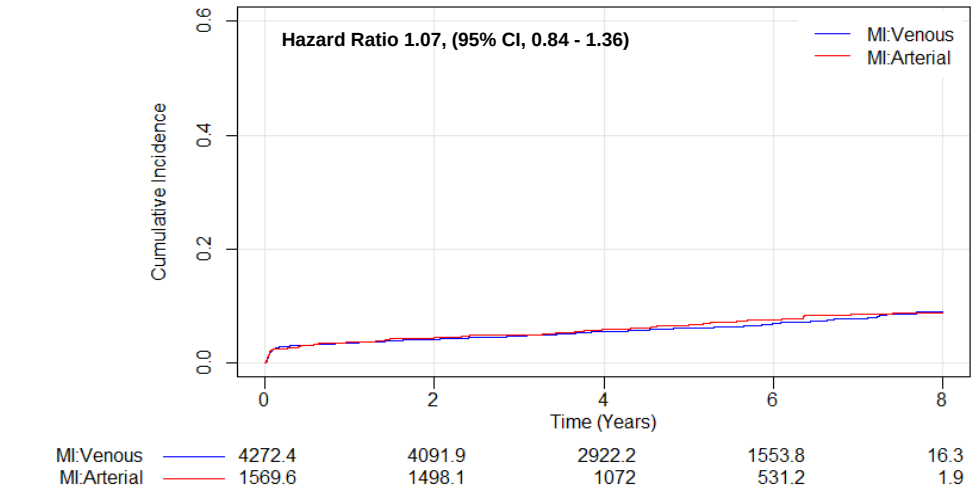
C Stroke



Stroke:Venous	5813	5676.8	4019.2	1957.7	11.1
Stroke:Arterial	5813	5710	4073	2109	17

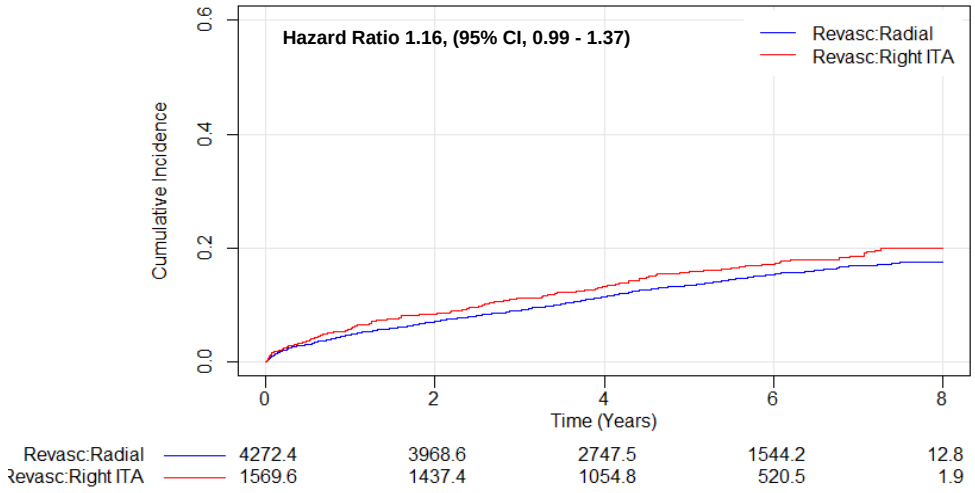
Supplemental Figure 9. Competing Risks of Myocardial Infarction, Repeat Revascularization, or Stroke with Death Among Recipients of Right Internal Thoracic Artery vs. Radial Artery Conduits

A Myocardial infarction



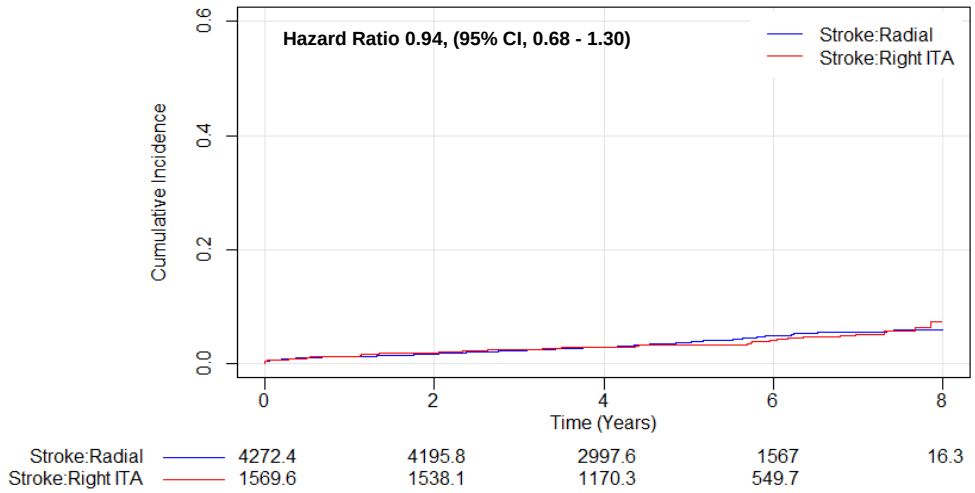
MI:Venous	4272.4	4091.9	2922.2	1553.8	16.3
MI:Arterial	1569.6	1498.1	1072	531.2	1.9

B Repeat revascularization



Revasc:Radial	4272.4	3968.6	2747.5	1544.2	12.8
Revasc:Right ITA	1569.6	1437.4	1054.8	520.5	1.9

C Stroke



Stroke:Radial	4272.4	4195.8	2997.6	1567	16.3
Stroke:Right ITA	1569.6	1538.1	1170.3	549.7	

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