Cost-effectiveness of Revascularization Strategies: Results from The American College of Cardiology Foundation and The Society of Thoracic Surgeons Collaboration on the Comparative Effectiveness of Revascularization Strategies (ASCERT)

Supplement Appendix

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Supplement: Life Expectancy Estimation

Using the observed mortality data in ASCERT and from Kaplan-Meier survival curves, stratified by age group (65-69, 70-74, 75-79, 80-84, 85- 90+), gender and race, we obtained probability of dying (q_x) for age group x, number surviving (l_x) to age group x, number dying (d_x) between groups x and x + 1, and person-years lived (L_x) between ages group x and (x+1), and then we calculated life expectation of life at age group x from life table formula. For instance, among white male patients in the group 65-69, we had q_x =0.0789, l_x=34,110, d_x=2,692, L_x=33, 889, and life expectation of 12.931 years with range from 11.08 to 13.52; the U.S. Life Tables 2008 (the latest date with available data) show that the same group had life expectation of 16.7 years with range from 15.3 to 18.1. After taking into account the range of variation by Monte Carlo simulation, the estimated lost life expectancy for white male patients in age group 65-69 would be 3.576 years with range from 2.225 to 4.383. Comparing with the corresponding life expectancy in the U.S. Life Tables, we derived the estimated lost life expectancy for sex and race in stratified age groups (65-69, 70-74, 75-79, 80-84, 85-90+). These estimates were then applied to the ACCF and STS patient populations.

Supplement: Propensity Model and included Variables

Propensity scores to estimate the probability of receiving CABG were developed with logistic regression to adjust for between-group differences in baseline patient and hospital characteristics (Rosenbaum PR, Rubin D. The central role of propensity score in observation studies for causal effects. Biometrika 1983;70:41-55.). C-index was 0.87. Patient-level covariates in the propensity model were: age, gender, race, height, BMI, smoking status, family history of coronary artery disease, GFR (defined as dialysis and/or GFR<=30), renal failure, hypertension, dyslipidemia, cerebrovascular disease, chronic lung disease, peripheral arterial disease, history of heart failure, prior PCI, prior myocardial infarction, angina prior to the procedure, ejection fraction, urgent procedure, number of diseased vessels, mitral insufficiency, mitral stenosis, aortic valve insufficiency and aortic stenosis. Hospital-level covariates were: hospital average annual PCI volume, hospital average annual CABG volume, academic hospital, and hospital location (rural/urban). For patients without renal failure, GFR was modeled as a linear trend between 30 and 90 and flat below 30 or above 90. Patients with renal failure were represented in the model by an indicator variable without further adjustment for GFR. The continuous variable ejection fraction was modeled as a linear trend. All other continuous variables were modeled as a flexible polynomial with linear and quadratic components.

Supplement: PSBB Approach

The PSBB approach addresses the means, adjusts for confounding factors, and does not make distributional assumptions, and it is a useful tool for cost-effectiveness analysis. First, the propensity score for each patient was computed as the probability of receiving CABG on the basis of baseline covariates, and the propensity scores were grouped into five strata of equal size determined by estimated propensity score quintiles; secondly, within each treatment group, bootstrap re-samples of fixed size are drawn within each stratum, with the total number of samples equating the total number of patients. For analysis comparing costs, the differences in mean total costs and effectiveness between treatment groups are computed for each replication, and a large number of replications generate the bootstrap distribution of mean and differences. Both cost and effectiveness measures are retained from each patient selected by the re-sampling and ICER is computed.

Supplement EuroScore II

Estimated logistic EuroScore II (mortality %) based on EuroScore II for each patient was also applied to estimate of life years gained over a life time. The EuroScore II ranges from 3 (mortality rate 1.82%) to 12 (mortality rate 33.93%) in CABG group and from 3 (mortality rate 1.82%) to 14 ((mortality rate 49.65%) in the PCI group. About 50% of patients in each group were categorized in the high risk group with EuroScore II of at least 6. For the matched analytic population, there was no significant difference (0.016, CI: -0.007, 0.039, p-value=0.18) in both EuorScore II and corresponding logistic Euroscore II (mortality) between the CABG (5.65, CI 5.64, 5.67) and PCI (5.64, CI: 5.62, 5.66) groups.

The raw EuroScore II difference between the CABG (5.47± 1.67) and PCI (5.87 ±1.84) group was 0.40 (0.3838, 0.4154, p-value=0.02). There was no significant difference (0.016, CI: -0.007, 0.039, p-value=0.18) in both EuroScore II and corresponding logistic Euroscore II (mortality) between the matched CABG (5.65, CI 5.64, 5.67) and PCI (5.64, CI: 5.62, 5.66) groups. Adjusted via PSBB, the EuroScore II difference between the CABG and PCI group was 0.0302 (0.0141, 0.0434, p-value=0.02).

Supplement Subgroup Analysis

The subgroup cost-effectiveness analyses were performed for the matched analytic population for the lifetime analysis. Similar results were obtained for all patients via PSBB (not shown). Results in Table 5 show differences in terms of patient features. It can be seen that the ICERs were $42,443 per QALY and $42,269 per QALY for stable angina and 2-vessel diseased patients, respectively, and both with 0% of estimates below $30,000 per QALY. It was found that the ICERs were $24,602 per QALY and $25,527 per QALY for CHF and no angina patients, respectively, and both with 100% of estimates below $30,000 per QALY. For age <75 year-old patients, the ICER of CABG compared to PCI was $29,182 per quality adjusted life year, with 75% of estimates below $30,000 per QALY, while for age >=75 year-old patients, the ICER was $32,118 per QALY, with less than 1% probability of estimates below $30,000/QALY. Among no diabetes patients, the ICER was $36,298 per QALY, with almost 0% of estimates was below $30,000/QALY; however, the ICER was $25,467 per QALY, with almost 100% of estimates below $30,000 per QALY for diabetes patients, indicating that CABG was more cost-effective for diabetes patients compared to non-diabetes. Similar results and trend can be seen for CHF and No CHF patients, as well 2-vessel diseases and 3/more-vessel diseased patients. In terms of angina, compared to PCI, patients in CABG group with stable angina cost the least with the least life year gained and with the highest ICER of $42,443 per QALY and 100% of estimates below $30,000 per QALY

Supplement Table 1. Health state specific life expectancy by age and gender from Framingham data

Age	Cardiovascular disease	Acute myocardial infarction	Stroke
Males			
50	15.9	13.9	N/A
60	12.3	10.8	7.98
70	8.78	7.48	5.50
80	5.26	4.30	3.75
Females			
50	20.3	14.9	N/A
60	16.1	11.6	9.81
70	11.0	7.18	7.11
80	7.02	5.34	4.96

Supplement Table 2 Effectiveness: Life Year Lost for each Procedure and Life Year Gained with CABG compared to PCI with matched pair for the Matched Analytic Population

Item	**CABG** (n=43,084)	**PCI** (n=43,084)	**Δ** **(CABG - PCI)**	**95% CI of Δ**
Period over 2004 through 2008				
Life year lost due to Death (3% discount)	1.0682	1.3355	0.2674	0.2252, 0.3086
Lifetime				
Estimated Life year lost (3% discount)	1.4260	1.7432	0.3172	0.2694, 0.3649
Quality adjusted Life year lost (3% discount)	1.1031	1.4977	0.3946	0.3554, 0.4339

Supplement Table 3 Costs of Index, period over 2004 through 2008 and lifetime by treatment group for the Matched Analytic Population

Item	**CABG** (n=43,084)	**PCI** (n=43,084)	**Δ (CABG - PCI)**	**95% CI of Δ**
Index hospitalization ($)	24,211	13,588	10,623	9,577, 11,625
From 2004 to 2008	64,739	56,660	8,079	7,033, 9,081
Lifetime	197,021	184,865	12,157	11,471, 13,519

Supplement Table 4: Characteristics of Variables in the Analysis of Probabilistic Sensitivity Analysis

Effectiveness		Base Value	Range	Distribution
	Cardiovascular Disease (Mortality)	0.0787	0.003, 0.20	Beta
	Acute myocardial Infarction (Prevalence)	0.1185	0.037, 0.30	Beta
	Stroke (Prevalence)	0.0257	0.016, 0.40	Beta
Cost				
	Revascularization Hospitalization	$10,500	$6,840, $12,340	Gamma
	Other cardiovascular Hospitalization	$9,700	$6,200, $11,880	Gamma
	Medication	$4,040	$2,100, $6,800	Log-normal
	Outpatient service	$7,200	$4,160, $10,450	Gamma
	After 2008 period	$46,500	$35,700, $100,750	Gamma

Supplement Figure 1: Process of selection patients in ASCERT