Circulation
JOURNAL OF THE AMERICAN HEART ASSOCIATION

American Heart Association®

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Circulation. published online May 8, 2013;
Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231

Print ISSN: 0009-7322. Online ISSN: 1524-4539

DOI: 10.1161/CIRCULATIONAHA.112.001330

Should Bilateral Internal Thoracic Artery (BITA) Grafting Be Used In Elderly Patients Undergoing Coronary Artery Bypass Grafting?

Running title: *Medalion et al.; Effect of age on outcome of BITA grafting*

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Journal Subject Code: Cardiovascular (CV) surgery:[36] CV surgery: coronary artery disease

Abstract:

***Background*—**Although Bilateral Internal Thoracic Artery (BITA) grafting is associated with improved survival, the use of this technique in elderly is controversial due to their increased surgical risk and shorter life expectancy. The purpose of this study is to evaluate the effect of age on outcome of patients undergoing BITA grafting.

***Methods and Results*—**Between 1996 and 2001, 1714 consecutive patients underwent skeletonized BITA grafting, of whom 748 were 65 years of age or younger, 688 were between 66 and 75 and 278 were 76 or older. Operative mortality of the three age groups (1.2%, 4.1% and 5.8%) was lower than the logistic Euroscore predicted mortality (3.9%, 6.5%, 9.3%, respectively, $p<0.001$). There was no significant difference between groups in occurrence of sternal infection (1.3%, 2.6% and 1.4% respectively, $p=0.171$). Mean follow-up was 11.5 years. Kaplan-Meier 10-year survival for patients ≤65, 66-75 and >75 years of age was 85%, 65% and 40%, respectively ($p<0.001$). They were better than the corresponding predicted Charlson Comorbidity Index survivals (68%, 37% and 20%, respectively, $p<0.001$ for all age groups), approaching survival of gender and age-matched general population (90%, 70% and 41%, respectively). Age 65 or younger (HR 0.232, 95% Ci 0.188-0.288) and 66-75 (HR 0.499, 95% Ci 0.414-0.602) were independent predictors of improved survival (Cox Model)

***Conclusions*—**BITA grafting should be considered in patients older than 65, due to the significant survival benefit obtained with this surgical technique without additional risk of sternal wound infection related to age.

Key words: cardiac surgery, elderly, bypass surgery

Introduction

With the expansion in life expectancy, an increasing number of elderly patients are referred for coronary artery bypass grafting (CABG), and the current trend is to use the internal thoracic artery (ITA) in all patients operated on, including the older ones. The current conventional and most commonly used operative procedure for myocardial revascularization includes one pedicled ITA together with one or more vein grafts[1,2]. Vein graft exhaustion is a major drawback of CABG, and surgical techniques of complete arterial myocardial revascularization without veins have been attempted. Two popular techniques for achieving this goal are bilateral and sequential ITA grafting[3].

When the ITA is dissected as a skeletonized artery[4], it becomes longer and its spontaneous blood flow is probably greater[5, 6] than that of the pedicled ITA, allowing the use of both ITAs to almost all coronary territories requiring bypass. In many patients, no additional vein grafts are required[7]. Another advantage of using ITA as a skeletonized artery is the preservation of collateral blood supply to the sternum[8], enabling more rapid healing, and decreasing the risk of infection[9, 10]. The bilateral skeletonized ITA technique was adapted in our service as the preferred method for myocardial revascularization[11, 12]. The purpose of the current report is to analyze the impact of age on the outcome of the first 1714 consecutive patients in whom we used this surgical technique.

Patients and Methods

From 1996 to 2001, 1714 consecutive patients underwent myocardial revascularization with BITAs that were dissected as skeletonized arteries[12]. They comprised 73% of the 2346 isolated CABG procedures for multi-vessel disease performed in the Tel Aviv Sourasky Medical Center during this period. Pre-operative and operative patients' data were collected from the hospital medical records after Institutional Review Board approvals. In order to evaluate the effect of age on early and long-term outcome, patients were stratified into three age groups: 65 years of age or younger, between 66 and 75 years, and 76 years or older. In order to evaluate the operative-period effect, patients were stratified according to their operative date into two groups: early (1996 to 1999) and late (2000-2001).

Expected operative mortality was calculated using the "Logistic Euroscore"[13] and compared to the observed early mortality. Expected mid- and long-term mortality without operation was calculated using the "Charlson Co-Morbidity Index" (C.C.I.)[14, 15, 16] (**Table 1**) and compared to the expected survival of the Israeli population of the same age and gender[17] and to the Kaplan-Meier actuarial survival. Follow-up was obtained using the Israeli National Registry database and a telephone questionnaire.

Surgical Techniques

Operations were performed using standard cardiopulmonary bypass (CPB) or off-pump coronary artery bypass (OPCAB). Myocardial preservation during CPB involved intermittent, antegrade or retrograde blood cardioplegia (30°C-32°C). Coronary stabilization during OPCAB was facilitated using CTS stabilizers (Curpentino, Calif.), or the Octopus system (Medtronic, Minneapolis, Minn.). ITAs were mobilized from the chest wall as skeletonized vessels. In 1515 of the cases[3], BITA were used to graft the left coronary system, i.e. the myocardial territory supplied by the left anterior descending and circumflex arteries. Left-sided revascularization was achieved using two basic arrangements: a free ITA (in most cases right ITA [RITA]) attached proximally end-to-side on the in-situ ITA (mostly left ITA) in a T-graft configuration (composite T-graft) and an in situ BITA with an ante-aortic crossover Right Internal Thoracic

Artery (RITA). The choice of configuration was determined by previously detailed technical considerations[18]. The type of conduit selected for right coronary artery (RCA) grafting was not related to the configuration of the ITAs. Our strategy was to use RITAs, Right Gastro-Epiploic Arteries (RGEA) and Radial Arteries (RA) as grafts to the RCA branches only in the presence of a significant stenosis (i.e. >80%)[19]. When the right coronary artery (RCA) system was unsuitable for arterial grafting, such as in cases with a potential for high competitive flow in the RCA, we selected saphenous vein grafts (SVG) as the conduit for revascularization of the RCA. To decrease the risk of spasm of the arterial grafts, all patients were treated with a high-dose intravenous infusion of isosorbide dinitrate (Isoket, 4 to 20 mg/h) during the first 48 hours postoperatively. Calcium-channel blockers (Dilitiazem; 90 to 180 mg/d, orally) were given to patients operated on using RGEA or RA from the second postoperative day for at least three months[12].

Definition of Terms and Data Collection

Patients' data were analysed according to ACC/AHA Clinical Data Standards[20]. Chronic renal failure (CRF) was diagnosed if the creatinine level exceeded 1.8 mg/dL. PVD included all symptomatic and asymptomatic extra-coronary arteriopathy. Cerebrovascular disease (CVD) included past history of any cerebrovascular event with or without permanent neurological damage. Our definition of "emergency operation" is based on the Society of Thoracic Surgeons guidelines and includes patients operated on within 24 hours of cardiac catheterization, with ongoing angina, acute evolving myocardial infarction, pulmonary edema or cardiogenic shock[21]. Patients who needed emergency surgery and were not stabilized after intra-aortic balloon counterpulsation were usually operated on using one ITA combined with SVGs and therefore were not included (**Table 2**). A perioperative myocardial infarction was defined by the appearance of new Q waves in the ECG associated with elevated levels of creatine phosphokinase-MB fraction >50 mU/ml. A cerebrovascular accident was defined as a new permanent neurological deficit and computed tomographic evidence of cerebral infarction. Deep sternal infection was defined as the sum of deep infection and late dehiscence requiring sternectomy.

Statistical Analysis

Data are expressed as the mean $\pm$ standard deviation or as a proportion. The χ^2 test and 2-sample *t* tests were used to compare discrete and continuous variables, respectively. Multivariable logistic regression analysis was used to predict early mortality and early morbidity events by various risk factors. The odds ratios (ORs) and 95% confidence intervals (CIs) are given. Postoperative survival of each age group was expressed by the Kaplan-Meier method and survival curves were compared by the Log Rank test. Cox proportional hazard model was used to evaluate the influence of preoperative variables (sex, period of surgery, age group, diabetes, COPD, CHF, CRF, PVD, recent MI, old MI, acute MI, unstable angina, preop IABP, emergency operation, EF$\leq$25%, number of vessels disease, left main disease), and operative data (repeat operation, OPCAB, number of grafts, bypass time, aortic cross clamp time, composite T-graft), on late and overall mortality. Cox model was used to compare adjusted survival between the various age groups after controlling for differences between groups in preoperative and operative characteristics. Results of Cox analysis were expressed as Hazard Ratios (HR) and the 95% Confidence Interval (CI).

To present the expected annual survival of the general population based on our sample of patients, we used the 2005-2009 Complete Life Tables published by the National Central Bureau of Statistics[17] to calculate the annual survival for each patient according to age and gender, up to 15 years. In addition, we used the Charlson index formulation to calculate the expected ten year survival of our patients, assuming no surgery was performed. The Charlson index formulation estimates survival of people according to their age and certain co-morbidities (Charlson index). It was validated for ten years survival[14]. For presentation purposes only, we extended the Charlson index formulation principal to calculate the estimated annual survival of each patient according to age and Charlson index, up to 15 years. The Charlson index formulation uses a ten year survival of a 40 year old person with no co-morbidities (98%) as the baseline survival for its calculations. We used the relative annual survival of a 40 years old person taken from the Israeli complete life tables[17] as the baseline survival, to calculate the annual estimated survival of each patient without surgery. However, since the Charlson index formulation was validated for ten years survival only, we performed formal statistical comparison of survival between the expected general population survival, observed actuarial survival, and estimated survival of the patients if no operation would have been performed, only at ten years using a one sample *t* test.

Statistical analysis was performed using SPSS for Windows version 19. Statistical significance was considered when $p<0.05$.

Results

Patients' preoperative characteristics by age groups are presented in **Table 3**. Patients' characteristics by operative period are presented in **Table 4**. **Table 2** compares patients' preoperative and operative characteristics to those of patients with multi-vessel disease operated on during the study period using single ITA (SITA). Operative mortality of the three age groups (1.2%, 4.1% and 5.8%) was lower than the Logistic Euroscore predicted mortality (3.9%, 6.5%

DOI: 10.1161/CIRCULATIONAHA.112.001330

and 9.3%, respectively, p<0.001). COPD (O.R. 3.145, 95% C.I. 1.402-7.042, p=0.005), preoperative old (O.R. 1.990, 95% C.I. 1.089-3.603, p=0.025) or acute (O.R. 2.915, 95% C.I. 1.570-5.405, p=0.001) MI, emergency operation (O.R. 3.39, 95% C.I. 1.855-6.211, p<0.001), and EF ≤25% (O.R. 3.47, 95% C.I. 1.036-11.627, p=0.044) were independent predictors of increased operative mortality. Age ≤65 was associated with reduced operative mortality (O.R. 0.236, 95% C.I. 0.098-0.566, p=0.001). Sternal infection occurred in 32 patients (1.9%) (**Table 5**). Increased prevalence of sternal complications was observed in patients with COPD (11.3%, p<0.001), repeat operation (9.5%, p<0.001), PVD (3.5%, p=0.004). Diabetes (3.4%, p=0.001) and patients operated on between 1996 and 1999 (early period 2.4%, p=0.001). Repeat operation (O.R. 6.289, 95% C.I. 1.945-20.408, p=0.002), COPD (O.R. 9.524, 95% C.I. 4.255-20.276, p<0.001), PVD (O.R. 2.155, 95% C.I. 1.036-4.484, p=0.04), Diabetes (O.R. 3.472. 95% C.I. 1.645-7.299, p=0.001), and early (1996-1999) operative period (O.R. 8.835, 95% C.I. 1.184-65.910, p=0.034) were identified as independent predictors of sternal wound infection.

Mean follow-up was 11.5 years. Kaplan-Meier 10-year survival for patients ≤65, 66-75 and >75 years of age were 85%, 65% and 41%, respectively (p<0.001). They were better than the corresponding predicted Charlson Comorbidity Index survivals (68%, 37% and 20%, respectively, p<0.001) for all age groups, approaching survival of gender and age-matched general population (90%, 70% and 40%, respectively) (**Figs. 1,2**). Predictors of decreased survival (Cox model) (**Table 6**) were older age (**Fig. 3**, p<0.001), congestive heart failure, diabetes, COPD, chronic renal failure, EF≤25%, repeat operation, PVD, preoperative IABP support and early operative period (**Fig. 4**, p=0.004).

Discussion

Surgical revascularization of the left anterior descending (LAD) artery with the internal thoracic artery (ITA) in patients with multi-vessel disease, is still the only proven method of improving event-free survival[22, 23]. ITA grafts, because of their resistance to atherosclerosis, have better long-term patency than saphenous vein grafts and this improved patency of ITA grafts is believed to be responsible for the better survival and decreased recurrence of angina and the need for reintervention when they are used to bypass the LAD[24].

Bilateral ITA (BITA) grafting is associated with improved survival, compared to single ITA and saphenous vein (SVG) grafting[25]. Besides improved survival, BITA patients had better event-free survival and reduced occurrence of re-interventions[25]. Despite the improved long-term outcome, the application of this technique in the elderly remains controversial due to their shorter life expectancy and in view of the excellent survival benefit obtained with single ITA. In addition, BITA grafting was associated with increased risk of sternal dehiscence and sternal infection[26, 27, 28] associated with the more extensive devascularization caused by harvesting two ITAs[29, 30].

In a later study by Lytle and associates[2], the number of patients older than 60 years operated on with bilateral ITA grafts was relatively small; however, bilateral ITA grafting improved survival of this subset of older patients when compared with patients older than 60 years with a single ITA graft.

In the above and other series[31, 32], extensive arterial grafting with bilateral ITAs was used preferentially in a selected group of young male non-obese non-diabetic patients. Patients were preselected for BITA grafting according to their life expectancy, and only few of the patients older than 70 years were offered the option of bilateral ITA grafting. The only large series (1467 patients) comparing bilateral with single ITA grafting in elderly patients was reported by Galbut and associates[33, 34]. In Galbut's study, patients with bilateral ITAs had a lower hospital mortality

(3.1%) than patients with a single ITA (6.4%), and the late survival (mean 43 months) was better as well (69.7% vs 60.7%).

Unlike in the above reports, in our series and that of Galbut and coworkers[33], old age was not a contraindication for BITA grafting. In our study, complete arterial grafting with bilateral ITAs was the preferred method of myocardial revascularization for all age groups. During the study period bilateral ITA grafting was performed in 61% of the patients referred for CABG, and 41% of them were 70 years or older.

Although this is a selected group of patients (**Table 2**), mortality and morbidity of our patients 70 years or older (3.7%) compared favorably with mortality described in procedures in which one ITA was used[1].

In the report by Lytle and colleagues[2], the only morbid event that differed between the bilateral and single ITA groups was the difference in sternal wound complication (2.5% and 1.4%, respectively). Harvesting the ITA as a wide musculo- fascial pedicle with the aid of electrocautery was shown to devascularize sternal collateral blood supply and expose the sternum to increased risk of poor healing, dehiscence, and infection[30]. The problem of poor healing due to insufficient collateral blood supply may be more important in the elderly patient. The sternum of elderly patients is sometimes more fragile because of osteoporosis and suboptimal blood supply.

Collateral blood flow to the sternum can be significantly improved by using the skeletonization technique when harvesting ITAs for BITA grafting[4, 5]. This new technique of ITA harvesting was already used in patients in the recently published ART trial. The ART trial is an ongoing randomized multicenter trial where 3102 patients were randomized to receive either BITA or SITA during CABG, with a primary outcome of survival at 10 years. Currently, only one year follow up is available[35]. Perioperative mortality was similar between groups (1.2%) and one year survival was not significantly different between groups.

Sternal wound reconstruction was higher in the BITA group (1.9%) compared to the SITA group (0.6%).

The authors concluded that BITA grafting is feasible. They also stressed that this are only early data from a long-term trial and follow-up will, in time, provide more definitive evidence on survival and morbidity.

The sternal wound reconstruction rate of the BITA group in the ART trial is identical to the occurrence of sternal complications in our previous publication describing routine use of skeletonized BITA grafting in a cohort of 1515 patients[3]. Occurrence of sternal complications (deep infection and dehiscence) in that study in patients older than 70 years was not significantly different than that of younger patients, and old age was not found to be an independent predictor of sternal complications.

A larger cohort of patients with longer follow-up is described in the current report. Occurrence of sternal complications in the three age groups was similar (1.3%, 2.4% and 1.4%, respectively, for ages ≤65, 66-75 and >75). The observed hospital mortality increased with increase in age (1.2%, 4.1% and 5.8%, respectively, for the three age groups in our report). However, it was significantly lower than the Euroscore calculated mortality (3.7%, 8.1% and 17.2%, $p<0.001$). Moreover, the actual ten year survival (Kaplan-Meier), as well as risk-adjusted (COX) survival estimates, are significantly better than the calculated Charlson's index ten year survival for all age groups (≤65, 66-75 and >75), suggesting significant survival benefit in BITA grafting, especially in the older age groups (**Figs. 1,2**), despite the fact that older age was associated with significantly decreased long-term survival.

In an effort to reduce the risk of sternal complications, we analyzed our long-term survival results and became more careful, in the later period, in patient selection for BITA grafting, especially in diabetic patients with COPD, repeat operations, female gender and obesity[3, 12, 18, 36, 37]. The decreased prevalence of COPD and obese diabetic females in the later period may be the explanation for decreased occurrence of sternal complications in that period.

Limitations:

1. This is a retrospective study and potential long-term benefits of BITA for elderly patients could not be demonstrated without comparing its outcome to that of CABG procedures incorporation one ITA and other conduits, such as SVG or radial arteries.

2. Postoperative angiograms and coronary CT angiograms were available only in a small number of patients, mostly in symptomatic patients. Therefore, they could not be included in this report.

In conclusion, our study suggests that the survival benefit of BITA grafting for all age groups outweighs the early adverse effect of sternal wound complications. Occurrence of these complications can be reduced by selective use of BITA grafting in patients undergoing CABG procedures.

Further studies are required to compare long-term outcome of BITA versus single internal thoracic artery (SITA) in elderly patients.

Conflict of Interest Disclosures: None.

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DOI: 10.1161/CIRCULATIONAHA.112.001330

Table 1. Charlson's Comorbidity Index.

Assigned weights for diseases	Conditions
1	Myocardial infarction
1	Congestive heart failure
1	Peripheral vascular disease
1	Cerebrovascular disease
1	Dementia
1	Chronic pulmonary disease
1	Connective tissue disease
1	Ulcer disease
1	Mild liver disease
1	Diabetes
2	Hemiplegia
2	Moderate or severe renal disease
2	Diabetes with end organ damage
2	Any tumor
2	Leukemia
2	Lymphoma
3	Moderate or severe liver disease
6	Metastatic solid tumor
6	AIDS

Assigned weights for each condition that a patient has. The total equals the score. Example: chronic pulmonary (1) and lymphoma (2) = total score (3).

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Table 2. Patients' Characteristics by surgical technique (SITA vs. BITA for Multi-Vessel Disease, 1996-2001).

	Prevalence		SITA (n=632)		BITA (n=1714)		P
Risk Factor	N	%	N	%	N	%	
Age ≤65	982	39.7	236	37.3	748	43.6	
Age 66-75	947	40.3	259	41.1	688	40.1	(0.002)
Age 76+	415	17.7	137	21.7	278	16.2	
Female	600	25.6	213	33.7	237	22.6	0.000
Diabetes	813	34.7	252	39.9	561	32.7	0.01
COPD	196	3.4	99	16.2	97	5.7	0.000
CHF	529	22.8	92	15.1	437	25.5	0.000
CRF	194	8.4	67	11	127	7.4	0.004
Old. MI >1 week	954	40.7	241	38.1	713	41.6	0.142
Acute MI ≤ 1 week	522	22.3	136	21.5	386	22.5	0.324
Unstable Angina	1510	64.4	518	82.1	992	57.9	0.000
EF ≤ 30%	195	8.3	42	6.6	153	8.9	0.043
Preop. IABP	160	6.8	60	9.5	100	5.8	0.002
Emergency op.	390	16.6	126	20	264	15.4	0.006
Repeat operation	72	3.1	30	4.7	42	2.5	0.004
Chronic CVD	244	10.4	90	14.2	154	9.0	0.000
PVD	577	24.6	145	22.9	432	25.2	0.141
3 Vessel Disease	1751	74.7	441	69.9	1310	76.5	0.001
Bypass Grafts ≥3	1698	72.9	421	66.6	1277	74.5	0.001
Left Main	636	27.1	172	27.3	464	27.1	0.486
OPCAB	465	19.8	111	17.6	354	20.7	0.052

Abbreviations: IDDM: Insulin-dependent diabetes mellitus;COPD: Chronic obstructive pulmonary disease; CHF: Congestive heart failure; CRF: Chronic renal failure; MI: Myocardial infarction; EF: Ejection fraction; IABP: Intra-aortic balloon pump; SITA: Single internal thoracic artery; BITA: Bilateral internal thoracic artery; OPCAB: Off-pump coronary artery bypass grafting; PVD: Peripheral vascular disease; CVD: Cerebro-vascular disease
*Critical preoperative state: any one or more of the following: ventricular tachycardia or fibrillation or aborted sudden death, preoperative cardiac massage, preoperative ventilation before arrival in the anaesthetic room, preoperative inotropic support, intra-aortic balloon counterpulsation or preoperative acute renal failure (anuria or oliguria<10 ml/hour).

DOI: 10.1161/CIRCULATIONAHA.112.001330

Table 3. Patients characteristics and age groups (N= 1714).

Factor	Total		Age ≤ 65		Age 66-75		Age ≥ >75		P
No.			748	43.6%	688	40.1%	278	16.7%	
Age (mean±SD)	65.6±10.9		56 ± 7.2		70 ± 2.8		79.3 ± 3.3		<0.001
Female gender	386	22.5%	114	15.2%	180	26.2%	92	33.1%	<0.001
NIDDM	529	30.9%	212	28.3%	242	35.2%	75	27%	0.006
IDDM	34	2%	19	2.5%	15	2.2%	0	0%	0.031
COPD	97	5.7%	33	4.4%	49	7.1%	15	5.4%	0.083
Congestive heart failure	437	25.5%	153	20.5%	182	26.5%	102	36.7%	<0.001
Chronic renal failure	127	7.4%	33	4.4%	53	7.7%	41	14.7%	<0.001
Peripheral vascular disease	432	25.2%	142	19%	189	27.5%	101	36.3%	<0.001
Cerbero-vascular disease	154	9%	39	5.2%	71	10.3%	44	15.8%	<0.001
EF≤25%	27	1.6%	12	1.6%	7	1.0%	8	2.9%	0.109
EF≤30%	153	8.9%	56	7.5%	66	9.6%	31	11.2%	0.137
3-vessel disease	1310	76.5%	552	73.8%	538	78.2%	220	79.4%	0.177
Acute MI≤1wk	386	22.5%	184	24.6%	148	21.5%	54	19.4%	0.151
Old MI >1 wk	713	41.6%	301	40.2%	287	41.7%	125	45%	0.393
Unstable angina pectoris	992	57.6%	409	54.7%	397	57.7%	186	66.9%	0.002
Left main disease	464	27.5%	162	21.7%	200	29.1%	102	36.8%	<0.001
Preop. IABP	100	5.8%	40	5.3%	37	5.4%	23	8.3%	0.166
Critical preoperative state	114.	6.7%	45	6.0%	43	6.3%	26	9.4%	0.140
Emergency operation	264	15.9%	108	14.4%	100	14.5%	56	20.1%	0.057
Repeat operation	42	2.5%	17	2.3%	17	2.5%	8	2.9%	0.855
Early operative period	1287	75%	567	76%	526	77%	194	70%	0.08
Logistic Euroscore (Mean±SD)	7.7 ±9.6		3.7 ± 3.8		8.1 ± 8.3		17.2 ± 15.0		<0.001
Charlson Comorbidity index score (Mean±SD)	2.03 ±1.60		1.74 ± 1.42		2.13 ± 1.66		2.56 ± 1.75		<0.001
OPCAB	354	20.7%	140	29.7%	137	20.0%	77	27.7%	0.006
Bypass grafts ≥ 3	1288	75.1%	590	78.9%	516	82.5%	182	65.4%	0.002
Composite T-graft	1023	59.7%	429	57.4%	415	60.3%	179	64.4%	0.113

NIDDM=noninsulin-dependent diabetes mellitus; IDDM=insulin dependent diabetes mellitus; lure; MI= myocardial infarction; EF= ejection fraction; IABP= intra-aortic balloon pump.

DOI: 10.1161/CIRCULATIONAHA.112.001330

Table 4. Patients' characteristics and operative period (early vs late)

Patient characteristics	Early (1996-1999) N=128	Late (2000-2001) N=427	P
Female	306 (23.8%)	80 (18.7%)	0.017
Emergency op.	214 (16.6%)	60 (11.2%)	0.008
Left main	333 (25.9%)	131 (30.8%)	0.029
COPD	80 (6.2%)	17 (4%)	0.05
MI (Old+Acute)	796 (61.8%)	221 (51.85)	<0.001
Acute MI	319 (24.8%)	67 (15.7%)	<0.001
EF≤30%	128 (9.95)	25 (5.9%)	0.005
Repeat operation	39 (3%)	3 (0.75)	0.003
OPCAB	181 (14.1%)	173 (40.6%)	<0.001
2VD	291 (22.6%)	76 (17.8%)	0.002
Bypass No. 2	271 (21.1%)	164 (36.1%)	<0.001
Composite graft	807 (62.7%)	216 (50.6%)	<0.001

Abbreviations: COPD: Chronic obstructive pulmonary disease; MI: Myocardial infarction; EF: Ejection fraction; OPCAB: Off-pump coronary artery bypass grafting

Table 5. Morbidity and Mortality By Age Group

Factor	**Total**		**Age <65**		**Age 65-75**		**Age >75**		**P**
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	
30 day mortality	53	3.1	9	1.2	28	4.1	16	5.8	<0.001
Deep sternal infection	32	1.9	10	1.3	18	2.6	4	1.4	0.171
Postop. CVA	53	3.1	12	1.6	31	4.5	10	3.6	0.006
Periop. MI	18	1.1	5	0.7	0	1.3	4	1.4	0.387
3 year actuarial survival	93±10		95.8±7%		88.1±12		77.5±25		0.001
5 year actuarial survival	88±10		94.1±9%		81.5±15		69.6±28		<0.001
10 year actuarial survival	70±10		84.7±13%		65.5±18		40.9±30		<0.001
CCI-10 year predicted survival	48±8		69±10		38±10		20±10		<0.001

Table 6. Independent predictors for overall mortality

		P
Age ≤65	HR 0.236, 95% C.I. 0.191-0.299	<0.001
Age 66-75	HR 0.503, 95% C.I. 0.417-0.606	
DM	HR 1.526, 95% C.I. 1.317-1.811	<0.001
COPD	HR 1.652, 95% C.I. 1.333-2.288	0.037
CHF	HR 1.834, 95% C.I. 1.449-2.212	<0.001
CRF	HR 1.360, 95% C.I. 1.067-1.731	0.031
PVD	HR 1.801, 95% C.I. 1.538-2.114	<0.001
IABP	HR 1.626, 95% C.I. 1.074-1.980	0.001
Redo	HR 1.623, 95% C.I. 1.076-2.445	0.021
EF 25	HR 2.132, 95% C.I. 1.201-3.021	0.001
Early period	HR 1.351, 95% C.I. 1.101-1.658	0.004

Abbreviations: DM: Diabetes mellitus; COPD: Chronic obstructive pulmonary disease; CHF: Congestive heart failure; CRF: Chronic renal failure; PVD: Peripheral vascular disease; IABP: Intra-aortic balloon pump; EF: Ejection fraction

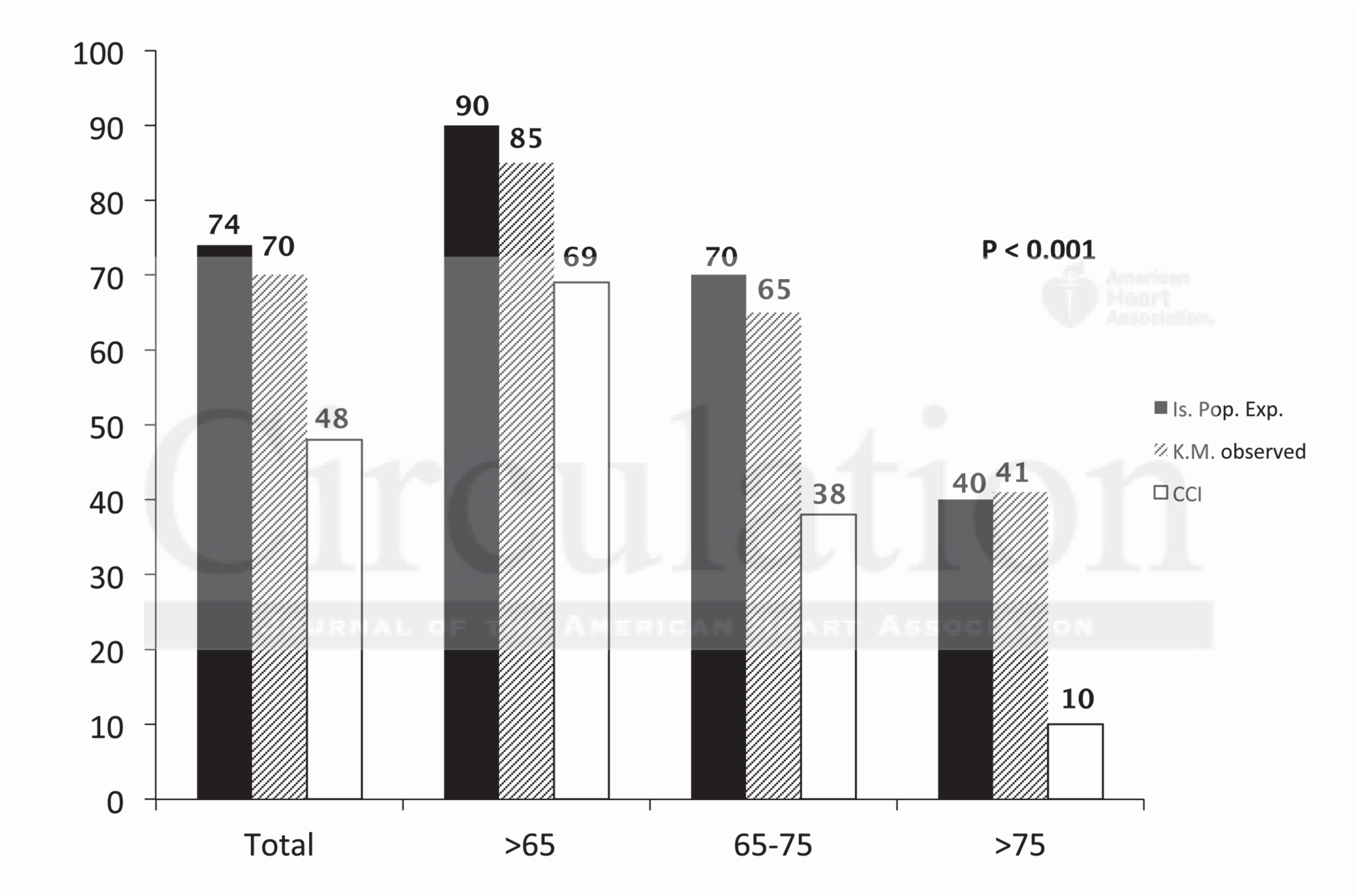
Figure Legends:

Figure 1. Kaplan-Meier survival and expected survival without operation (Israeli Population and Charlson Comorbidity Index, C.C.I.).

Figure 2. Expected (Charlson's Comorbidity index) versus Israeli Population expected survival without operation and observed (Kaplan-Meier) 10 year survival by age groups (p<0.001) for all pairwise comparisons of each age group – a. age ≤65, b. age 66-75, c. age >75.

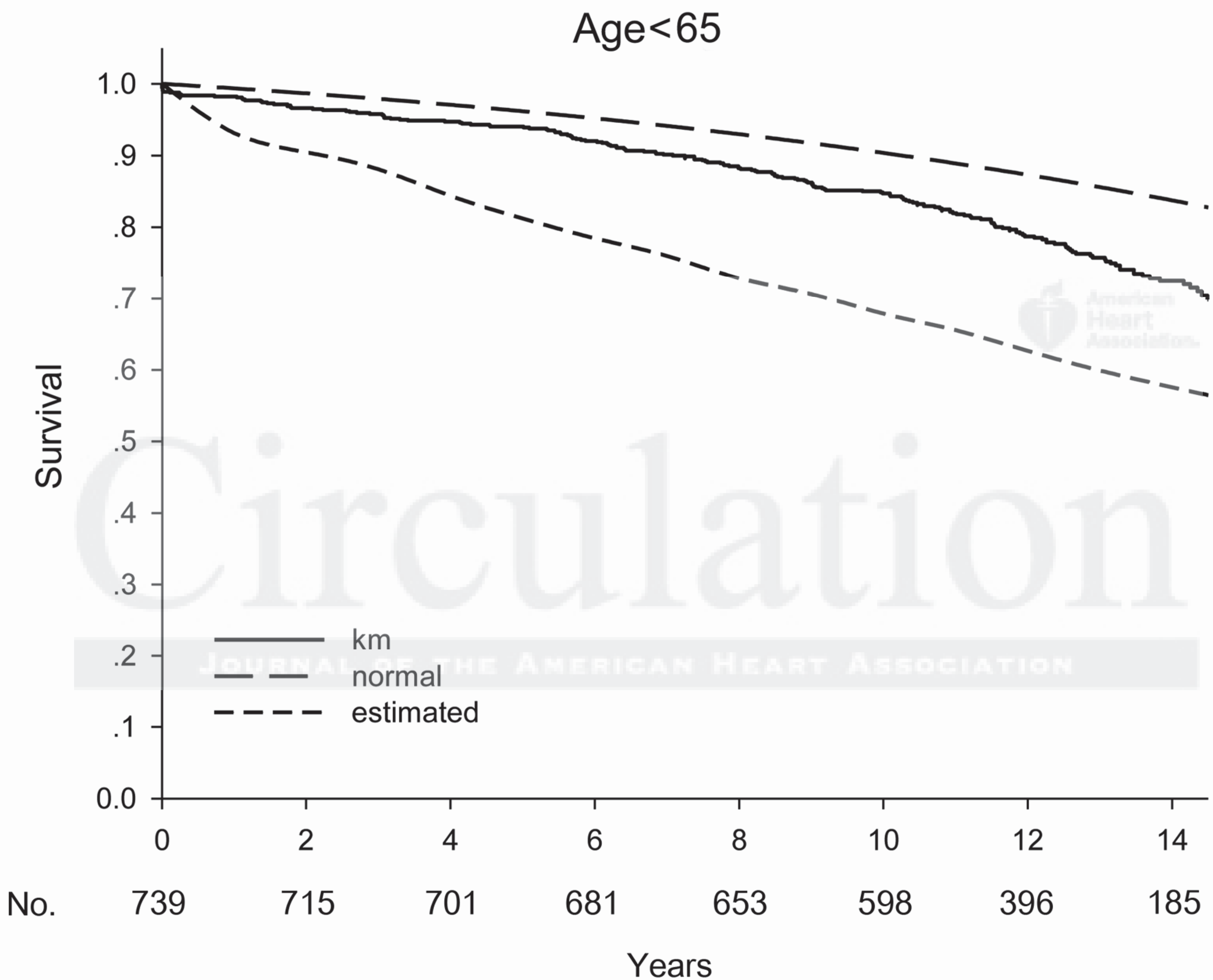
Figure 3. Cox-adjusted survival by age group.

Figure 4. Long-term adjusted survival (Cox) by operative period.



100
90
80
70
60
50
40
30
20
10
0
74
70
48
90
85
69
70
65
38
40
41
10
P < 0.001
Is. Pop. Exp.
K.M. observed
CCI
Total
>65
65-75
>75

Figure 1


Age<65
Survival
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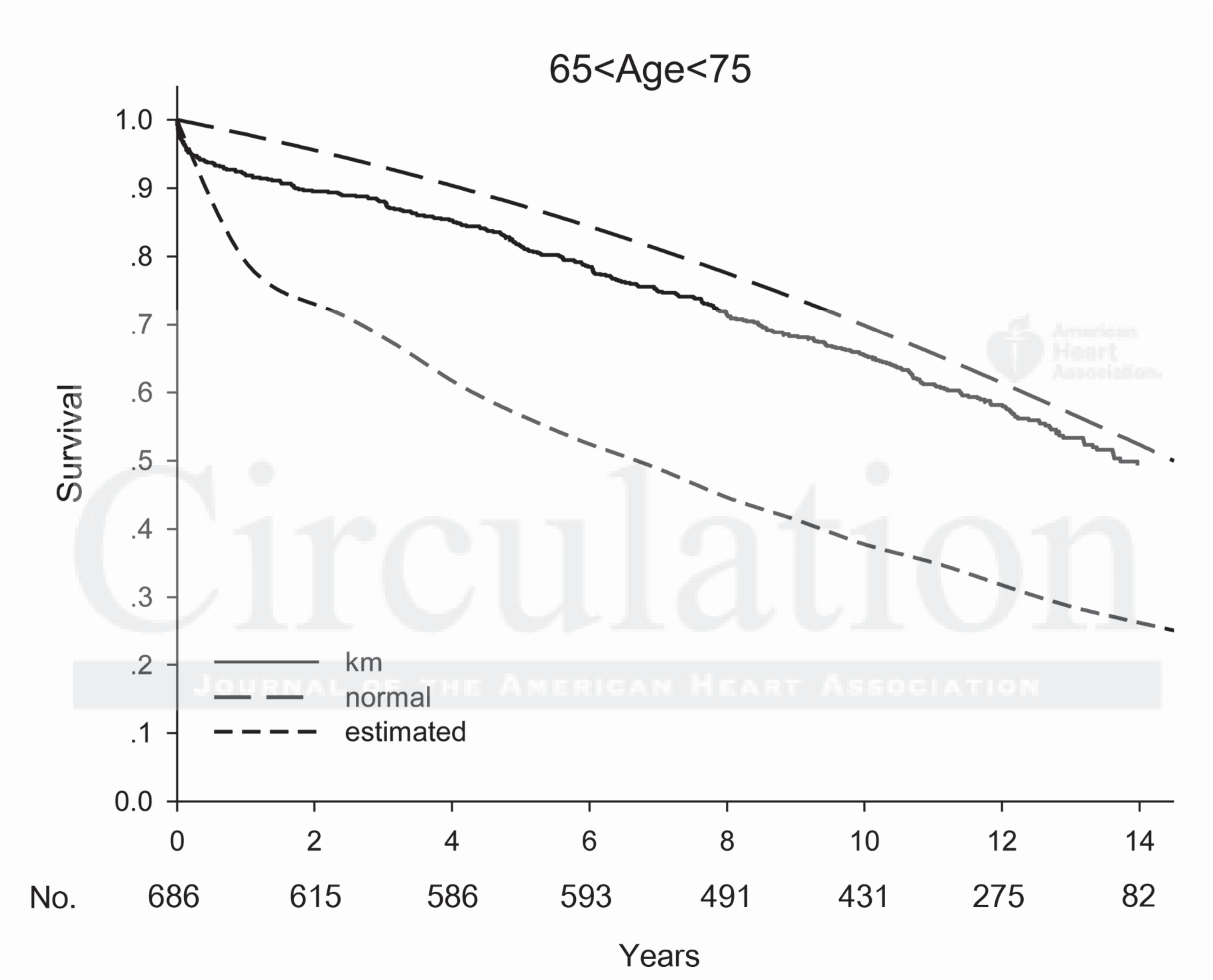
.9
.8
.7
.6
.5
.4
.3
.2
.1
0.0
0
2
4
6
8
10
12
14
km
normal
estimated
No.
739
715
701
681
653
598
396
185
Years

Figure 2A



65<Age<75
Survival
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
0.0
km
normal
estimated
0
2
4
6
8
10
12
14
No.
686
615
586
593
491
431
275
82
Years

Figure 2B

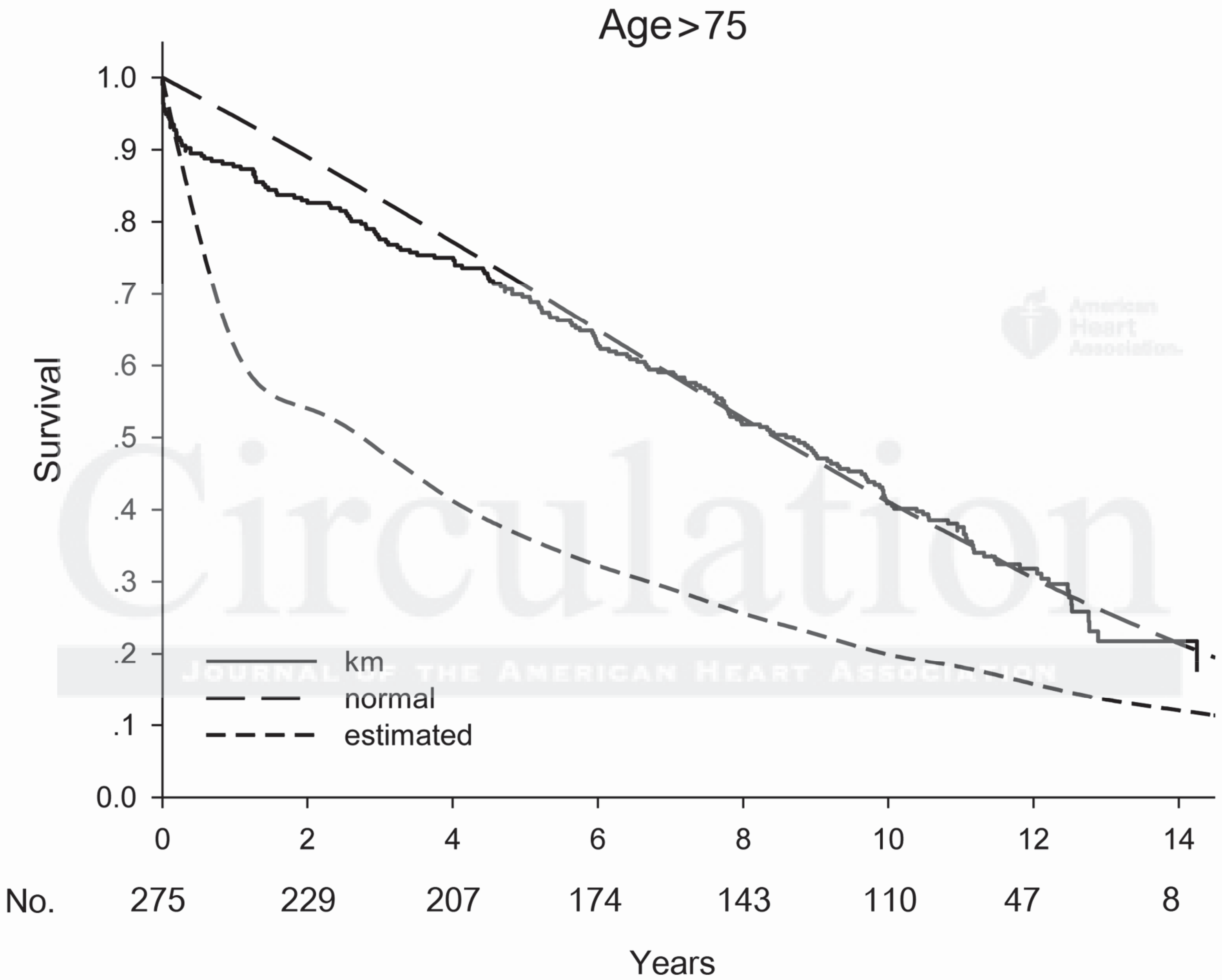

Age>75
Survival
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
0.0
km
normal
estimated
0
2
4
6
8
10
12
14
No.
275
229
207
174
143
110
47
8
Years

Figure 2C

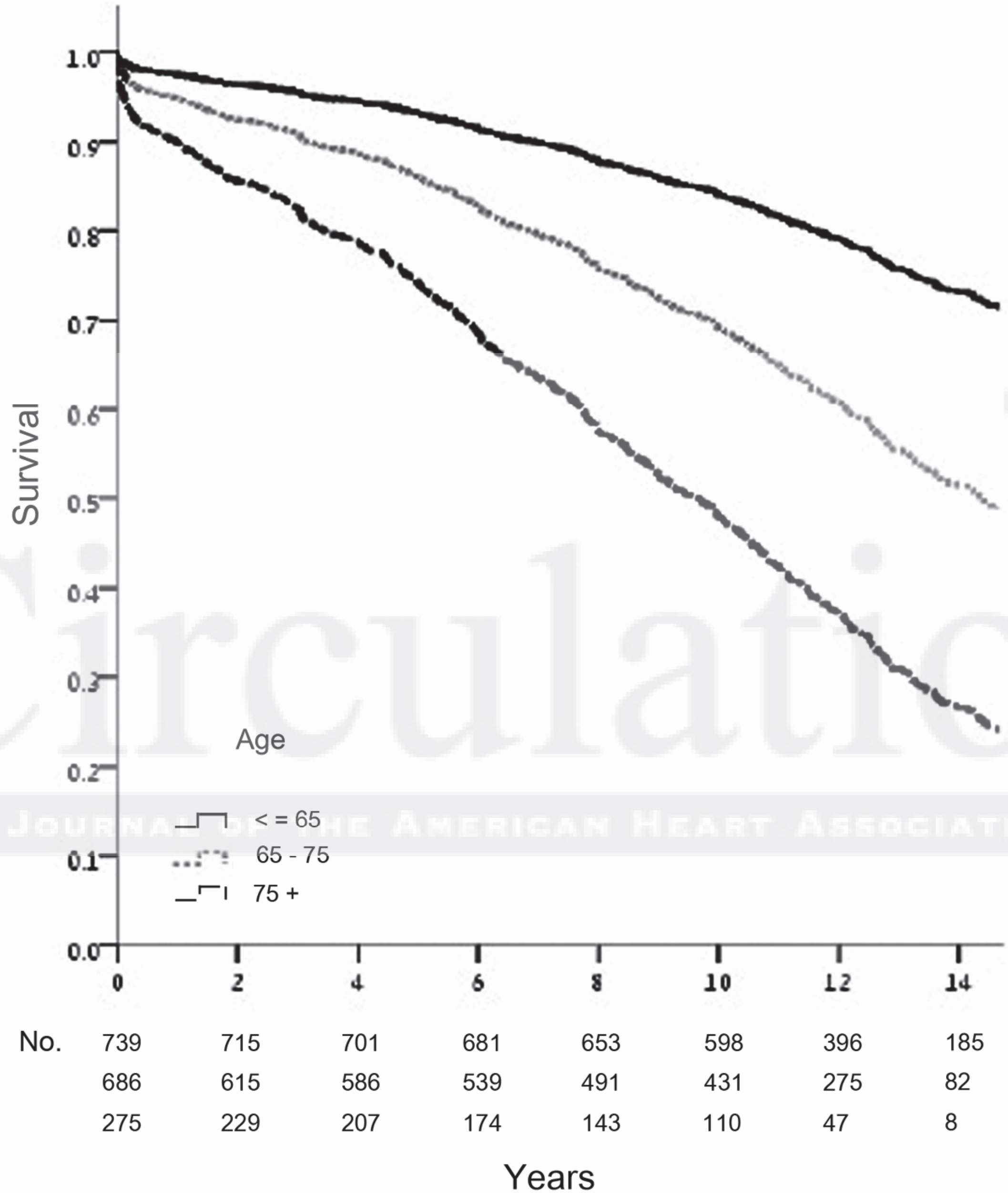

Survival
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Age
< = 65
65 - 75
75 +
0
2
4
6
8
10
12
14
No. 739 715 701 681 653 598 396 185
686 615 586 539 491 431 275 82
275 229 207 174 143 110 47 8
Years

Figure 3

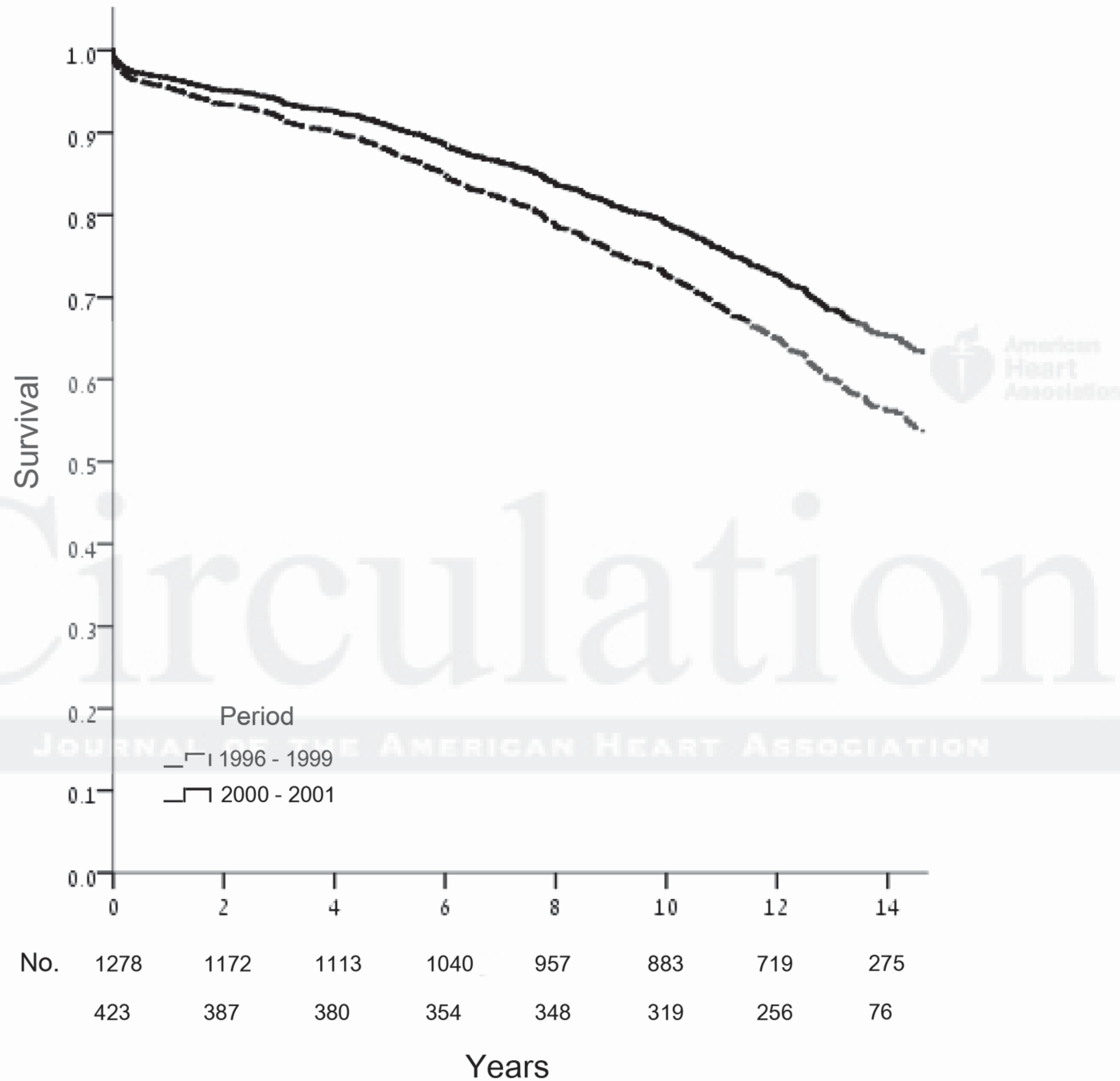

1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Survival
Period
1996 - 1999
2000 - 2001
0
2
4
6
8
10
12
14
No.
1278 1172 1113 1040 957 883 719 275
423 387 380 354 348 319 256 76
Years

Figure 4