rate of 11.8%. Lung resection combined with esophagectomy was performed in 48 patients, with a 30-day mortality rate of 2.1% and a hospital mortality rate of 6.3%.

Salvage surgery after definitive (chemo) radiotherapy was performed in 203 patients, with a 30-day mortality rate of 0.5% and a hospital mortality rate of 3.9% (Table 5).

Lastly, despite the efforts of the Committee to cover wider patient populations for this annual survey, most of the institutions that responded to the questionnaire were the departments of thoracic or esophageal surgery. It should be noted that a larger number of patients with esophageal diseases may have been treated medically and endoscopically. We should continue our efforts for a complete survey through more active collaboration with the Japan Esophageal Society and other related societies.

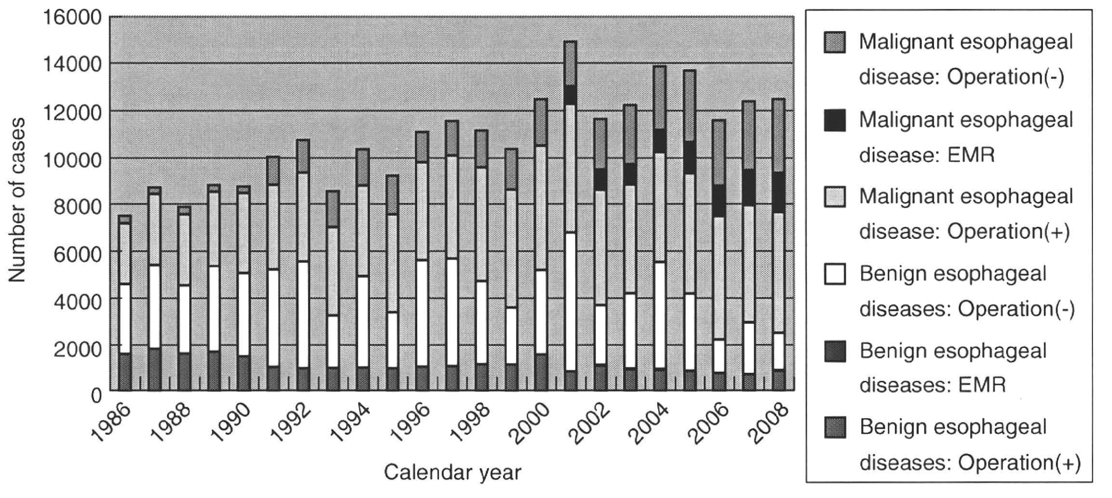


Fig. 1 Annual trend of in-patients with esophageal diseases. *EMR*, endoscopic mucosal resection (including endoscopic submucosal dissection)

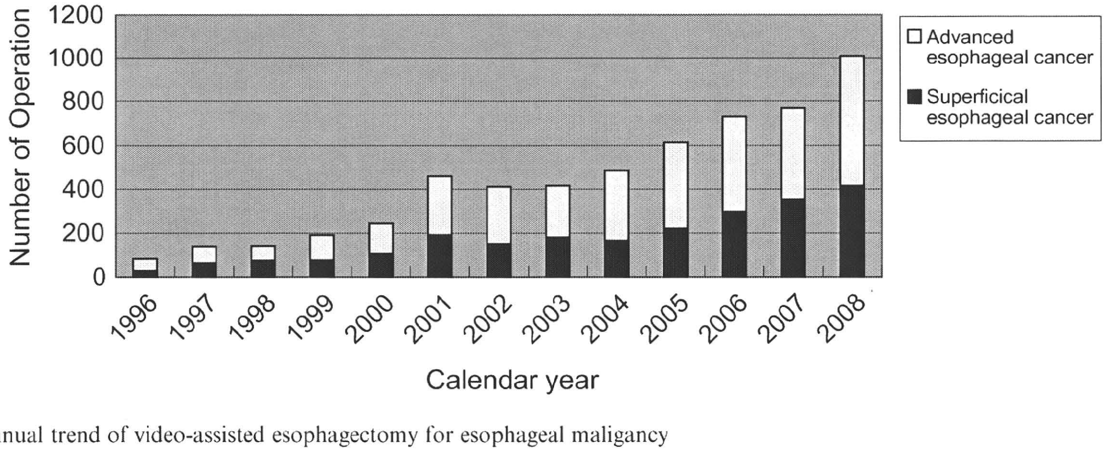


Fig. 2 Annual trend of video-assisted esophagectomy for esophageal maligancy

Table 1 Distribution of the number of esophageal operations in 2008 at the institutions in 2008

Esophageal surgery			
No. of operations in 2007	Benign esophageal disease	Malignant esophageal disease	Benign + malignant disease
1–4	196	195	184
5–9	34	108	121
10–19	15	86	92
20–29	1	28	36
30–39	1	22	25
40–49	0	10	11
≥50	2	27	32
Total	249	476	501

Table 2 Benign esophageal diseases in 2008

	Operation(+)									Endoscopic resection	Operation (−)	Total
	No. of patients			30-Day mortality			Hospital mortality					
	Total	Open	T/L	Total	Open surgery	T/L	Total	Open surgery	T/L			
1. Achalasia	164	28	136	0	0 (0.0)	0	3	3 (10.7)	0		52	216
2. Benign tumor	60	32	28	0	0 (0.0)	0	0	0 (0.0)	0	29	74	163
(1) Leiomyoma	38	18	20	0	0 (0.0)	0	0	0 (0.0)	0	15	64	117
(2) Cyst	4	3	1	0	0 (0.0)	0	0	0 (0.0)	0	1	4	9
(3) Others	18	11	7	0	0 (0.0)	0	0	0 (0.0)	0	13	5	36
(4) Not specified			0	0	0	0	0	0	0	0	1	1
3. Diverticulum	20	12	8	0	0 (0.0)	0	0	0 (0.0)	0		24	44
4. Hiatal hernia	233	85	148	0	0 (0.0)	0	0	0 (0.0)	0		150	383
5. Spontaneous rupture of the esophagus	71	69	2	3	3 (4.3)	0	5	5 (7.2)	0		12	83
6. Esophagotracheal fistula	12	12	0	0	0 (0.0)	0	1	1 (8.3)	0		11	23
7. Congenital esophageal atresia	56	54	2	0	0 (0.0)	0	0	0 (0.0)	0		16	72
8. Congenital esophageal stenosis	5	4	1	0	0 (0.0)	0	0	0 (0.0)	0		4	9
9. Corrosive stricture of the esophagus	5	3	2	0	0 (0.0)	0	0	0 (0.0)	0		8	13
10. Esophagitis, Esophageal ulcer	58	31	27	0	0 (0.0)	0	0	0 (0.0)	0		304	362
11. Esophageal varices	145	141	4	2	2 (1.4)	0	2	2 (1.4)	0		871	1,016
(1) Laparotomy	25	21	4	2	2 (9.5)		2	2 (9.5)	0			25
(2) Others				0			0					0
(3) Sclerotherapy				0			0				608	608
12. Others	43	33	10	3	3 (9.1)	0	4	3 (9.1)	1		88	131
Total	872	504	368	8	8 (1.6)	0	15	14 (2.8)	1	29	1,614	2,515

( ), % mortality; T/L, thoracoscopic and/or laparoscopic resection

Table 3 Malignant esophageal diseases (histological classification) in 2008

	Resection(+)	Resection(−)	Total
Carcinomas	6,654	3,121	9,775
1. Squamous cell carcinoma	6,053	2,989	9,042
2. Basaloid(-squamous) carcinoma	100	4	104
3. Carcinosarcoma	40	6	46
4. Adenocarcinoma in the Barrett's esophagus	229	20	249
5. Other adenocarcinoma	112	26	138
6. Adenosquamous carcinoma	23	3	26
7. Mucoepidermoid carcinoma	3	1	4
8. Adenoid cystic carcinoma	0	0	0
9. Endcrine cell carcinoma	17	18	35
10. Undifferentiated carcinoma	27	26	53
11. Others	9	28	37
12. Redundant	(1)		
13. Unknown	41	0	
Other malignancies	35	11	46
1. Malignant nonepithelial tumors	8	0	8
2. Malignant melanoma	18	8	26
3. Other malignant tumors	9	3	12
Not specified	141	11	152
Total	6,830	3,143	9,973

Resection includes endoscopic resection

Table 4 Malignant esophageal disease (clinical characteristics) in 2008

	Operation(+)			EMR	Operation(−)	Total
	Cases	30-Day mortality	Hospital mortality			
1. Esophageal cancer	5,124	63 (1.2)	144 (2.8)	1,705	3,144	9,973
A. Location						0
(1) Cervical esophagus	208	0 (0.0)	5 (2.4)	49	271	528
(2) Thoracic esophagus	4,231	57 (1.3)	130 (3.1)	1,426	2,611	8,268
(3) Abdominal esophagus	424	3 (0.7)	6 (1.4)	81	84	589
(4) Multiple cancers	249	3 (1.2)	3 (1.2)	148	120	517
(5) Others/not described	12	0	0	1	58	71
B. Tumor depth						
(1) Superficial cancer	1,398	8 (0.6)	21 (1.5)	1,705	353	3,456
(2) Advanced cancer	3,723	54 (1.5)	119 (3.2)		2,680	6,403
(3) Not specified	3	1	4		111	114
2. Multiple primary cancers	719	6 (0.8)	17 (2.4)	369		1,088
A. Synchronous	473	3 (0.6)	10 (2.1)	138		611
(1) Head and neck	147	0 (0.0)	0 (0.0)	66		213
(2) Stomach	195	2 (1.0)	7 (3.6)	48		243
(3) Others	11	1 (9.1)	2 (18.2)	11		22
(4) Triple cancers	30	0 (0.0)	1 (3.3)	9		39
(5) Not specified				4		
B. Metachronous	246	3 (1.2)	7 (2.8)	231		477
(1) Head and neck	62	1 (1.6)	2 (3.2)	82		144
(2) Stomach	69	2 (2.9)	3 (4.3)	73		142
(3) Others	103	0 (0.0)	2 (1.9)	55		158
(4) Triple cancers	12	0 (0.0)	0 (0.0)	27		39

( ), % mortality; EMR, endoscopic mucosal resection (including endoscopic submucosal dissection)

Table 5 Malignant esophageal disease (surgical procedures) in 2008

	Cases	30-Day mortality	Hospital mortality
Superficial cancer			
1. Endoscopic mucosal resection	1,705	0 (0.0)	0 (0.0)
2. Esophagectomy	1,398	8 (0.6)	21 (1.5)
(1) Transhiatal esophagectomy	68	0 (0.0)	1 (1.5)
(2) Thoracoscopic and/or laparoscopic procedure	416	1 (0.2)	4 (1.0)
(3) Transthoracic (rt.) esophagectomy and reconstruction	824	3 (0.4)	11 (1.3)
(4) Transthoracic (lt.) esophagectomy and reconstruction	25	0 (0.0)	0 (0.0)
(5) Cervical esophageal resection and reconstruction	7	0 (0.0)	0 (0.0)
(6) Two-stage operation	15	1 (6.7)	1 (6.7)
(7) Others/not specified	43	3 (7.0)	4 (9.3)
Advanced cancer			
1. Endoscopic mucosal resection	0		
2. Esophagectomy	3,723	54 (1.5)	119 (3.2)
(1) Transhiatal esophagectomy	71	2 (2.8)	5 (7.0)
(2) Thoracoscopic and/or laparoscopic procedure	593	10 (1.7)	19 (3.2)
(3) Transthoracic (rt.) esophagectomy and reconstruction	2,693	39 (1.4)	84 (3.1)
(4) Transthoracic (lt.) esophagectomy and reconstruction	143	2 (1.4)	3 (2.1)
(5) Cervical esophageal resection and reconstruction	95	0 (0.0)	1 (1.1)
(6) Two-stage operation	50	1 (2.0)	6 (12.0)
(7) Others/not specified	79	0 (0.0)	1 (1.3)
(Depth not specified)	3	1	4
Combined resection of other organs	250	2 (0.8)	6 (2.4)
1. Aorta	0	0 (0.0)	0 (0.0)
2. Trachea, bronchus	17	1 (5.9)	2 (11.8)
3. Lung	48	1 (2.1)	3 (6.3)
4. Others	185	0 (0.0)	1 (0.5)
Salvage surgery	203	1 (0.5)	8 (3.9)

Table 6 Mortality after combined resection of the neighbouring organs in 2008

	Esophagectomy			Combined resection											
				Aorta			Tracheobronchus			Lung			Others		
Year	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
1996	4,194	120	2.86%	7	3	42.86%	24	0	0.00%	50	2	4.00%	78	4	5.13%
1997	4,441	127	2.86%	1	0	0.00%	34	5	14.71%	56	1	1.79%	94	3	3.19%
1998	4,878	136	2.79%	4	0	0.00%	29	0	0.00%	74	1	1.35%	128	2	1.56%
1999	5,015	116	2.31%	5	0	0.00%	23	2	8.70%	68	0	0.00%	122	1	0.82%
2000	5,350	81	1.51%	2	0	0.00%	23	2	8.70%	69	0	0.00%	96	1	1.04%
2001	5,521	110	1.99%	1	0	0.00%	26	1	3.85%	83	3	3.61%	99	2	2.02%
2002	4,904	66	1.35%	3	1	33.33%	20	2	10.00%	63	0	0.00%	63	1	1.59%
2003	4,639	45	0.97%	0	0	0.00%	24	2	8.33%	58	0	0.00%	88	1	1.14%
2004	4,739	64	1.35%	2	0	0.00%	17	0	0.00%	59	5	8.47%	119	2	1.68%
2005	5,163	52	1.01%	1	0	0.00%	11	1	9.09%	67	1	1.49%	73	1	1.37%
2006	5,236	63	1.20%	0	0	0.00%	17	0	0.00%	62	2	3.23%	122	3	2.46%
2007	4,990	60	1.20%	0	0	0.00%	25	1	4.00%	44	1	2.27%	138	2	1.45%
2008	5,124	63	1.23%	0	0	0.00%	17	1	5.88%	48	1	2.08%	185	0	0.00%
Total	64,194	1,103	1.76%	26	4	15.38%	290	17	5.86%	801	17	2.12%	1,405	23	1.64%

a, number of patients who underwent the operation
b, number of patients who died within 30 days after the operation
c, % ratio of b/a (i.e., direct operative mortality)

Acknowledgements On behalf of The Japanese Association for Thoracic Surgery, the authors thank the heads of the Affiliate and Satellite Institutes of Thoracic Surgery for their cooperation and the Councilors of the Japan Esophageal Society.

Reference

1. Comittee of Scientific Affairs. Thoracic and cadiovascular surgery in Japan during 2007. Annual report of the Japanese Association for Thoracic Surgery. Gen Thorac Cardiovasc Surg 2009;57:488–513.

Members of the Committee for Scientific Affairs

Ryuzo Sakata, MD, Yoshitaka Fujii, MD, Tomoyuki Goya, MD, Koichi Kaneko, MD, Hiroyuki Kuwano, MD, Arata Murakami, MD, Kiyoharu Nakano, MD, Hiroshi Nishida, MD, Yutaka Okita, MD, Soji Ozawa, MD, Yuzuru Sakakibara, MD, Kisaburou Sakamoto, MD, Yuichi Ueda, MD

Difference in Patient Profiles and Outcomes in Japanese Versus American Patients Undergoing Coronary Revascularization (Collaborative Study by CREDO-Kyoto and the Texas Heart Institute Research Database)

Shun Kohsaka, MD[a,*], Takeshi Kimura, MD, PhD[c], Masashi Goto, MD, MPH, PhD[e], Vei-Vei Lee, MS[b], MacArthur Elayda, MD, PhD[b], Yutaka Furukawa, MD, PhD[f], Masanori Fukushima, MD, PhD[g], Masashi Komeda, MD, PhD[h], Ryuuzou Sakata, MD, PhD[d], James T. Willerson, MD[a], James M. Wilson, MD[a], and Toru Kita, MD, PhD[f]

Although coronary revascularization is common in both Japan and the United States (US), no direct comparison has been performed to demonstrate differences in the clinical characteristics and long-term outcomes of patients in these 2 countries. We analyzed the preprocedural, in-hospital, and long-term data from the Coronary Revascularization Demonstrating Outcome registry (Kyoto, Japan) and the Texas Heart Institute Research Database (Houston, Texas) of 16,100 patients who had undergone elective, initial percutaneous coronary intervention or coronary artery bypass grafting. The Japanese procedures were performed from 2000 to 2002 (n = 8,871, follow-up period 3.5 years, interquartile range 2.6 to 4.3) and the US procedures from 1999 to 2003 (n = 7,229, follow-up period 5.2 years, interquartile range 3.8 to 6.5). The Japanese patients tended to be older (mean age 67.2 vs 62.7 years; p <0.001), to smoke (52.9% vs 46.0%; p <0.001), and to have diabetes (39.2% vs 31.0%; p <0.001) and stroke (16.4% vs 5.0%; p <0.001). The US patients were more obese (body mass index 23.7 vs 29.3 kg/m^2; p <0.001), with greater rates of systemic atherosclerotic disease. Both groups had a similar in-hospital mortality rate (Japanese patients 0.9% vs US patients 1.1%; p = 0.19) and crude long-term mortality rate (Japanese patients 27.7/1,000 person-years, US patients 28.2/1,000 person-years; p = 0.35). After adjustment for known predictors, the US group had greater long-term mortality than the Japanese group (hazard ratio 1.71, 95% confidence interval 1.50 to 1.95; p <0.001). This finding was consistent among all high-risk subgroups. In conclusion, the 2 registries showed similar crude outcomes but important differences in patient risk factors such as obesity. In the adjusted analysis, the Japanese patients had better outcomes than did the US patients. Additional study is needed to assess the effect of ethnic and risk factor variations on coronary artery disease. **(Am J Cardiol 2010;105:1698–1704)**

Physicians in both Japan and the United States (US) perform a high volume of coronary revascularization procedures; however, the ethnicities and lifestyles of their patients differ greatly.[1,2] In Western countries, several large-scale databases of patients with coronary artery disease (CAD) have been established.[3,4] Despite the large number of subjects enrolled in these studies, the Asian subgroup has been relatively small. Furthermore, few studies have been conducted in Asian countries, mainly because patients have been hesitant to enroll in clinical trials and sufficient resources are lacking to maintain large databases. Hence, little is known about the clinical presentation and postrevascularization outcomes of Asian patients with CAD or about how these patients compare with their counterparts in the US. To help fill this void, we assessed the clinical characteristics and long-term outcomes of Japanese versus US patients by comparing information from 2 large databases concerning percutaneous coronary intervention (PCI) and coronary artery bypass grafting (CABG) in these 2 countries.

Divisions of [a]Cardiology and [b]Biostatistics, Texas Heart Institute at St. Luke's Episcopal Hospital, Houston, Texas; Departments of [c]Cardiovascular Medicine and [d]Cardiovascular Surgery, Kyoto University Graduate School of Medicine, Kyoto, Japan; [e]Kyoto University Health Service, Kyoto, Japan; [f]Division of Cardiology, Kobe City Medical Center General Hospital, Kobe City, Japan; [g]Translational Research Center, Kyoto University Hospital, Kyoto, Japan; and [h]Department of Cardiovascular Surgery, Nagoya Heart Center, Nagoya, Japan. Manuscript received October 15, 2009; manuscript received and accepted January 20, 2010.

Dr. Kohsaka is currently appointed with Keio University, School of Medicine, Tokyo, Japan.

This work was supported by an educational grant from the Research Institute for Production Development (Kyoto, Japan), Grant-in-Aid for Young Scientist (KAKENHI) from the Ministry of Education, Culture, Sports, Science and Technology (Tokyo, Japan) and the Grant for Clinical Vascular Function Kimura Memorial Cardiovascular Foundation (Tokyo, Japan).

Drs. Kohsaka and Goto had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

*Corresponding author: Tel: (713) 529-5530; fax: (713) 791-1786.
E-mail address: sk2798@columbia.edu (S. Kohsaka).

0002-9149/10/$ – see front matter
doi:10.1016/j.amjcard.2010.01.349

Table 1
Patient demographic data stratified by registry and revascularization procedure

Variable	Missing Data	Japan (n = 8,871)	United States (n = 7,229)	p Value	PCI			CABG		
					Japanese Patients (n = 6,510)	US Patients (n = 4,076)	p Value	Japanese Patients (n = 2,361)	US Patients (n = 3,153)	p Value
Age (years)	0	67.2 ± 10.0	62.7 ± 11.1	<0.001	67.2 ± 10.2	62.4 ± 11.6	<0.001	67.1 ± 9.4	63.1 ± 10.6	<0.001
Women	0	29.1%	29.9%	0.28	29.7%	32.4%	0.003	27.6%	26.7%	0.46
Body mass index (kg/m^2)	439	23.7 ± 3.2	29.3 ± 5.8	<0.001	23.7 ± 3.3	29.6 ± 6.1	<0.001	23.5 ± 3.2	28.9 ± 5.4	<0.001
Coronary artery bypass grafting	0	26.6%	43.6%	<0.001						
History of myocardial infarction	80	26.3%	34.3%	<0.001	23.3%	33.6%	<0.001	34.5%	35.1%	0.62
History of heart failure	99	15.4%	14.0%	0.013	12.1%	11.4%	0.30	24.7%	17.4%	<0.001
New York Heart Association functional class IV	105	1.4%	7.4%	<0.001	1.5%	6.3%	<0.001	1.3%	8.7%	<0.001
Peripheral vascular disease	76	11.3%	14.7%	<0.001	8.1%	12.7%	<0.001	20.1%	17.3%	0.008
Cerebrovascular disease	75	16.4%	5.0%	<0.001	14.1%	4.1%	<0.001	22.7%	6.1%	<0.001
Valve disease	85	7.6%	6.1%	<0.001	7.7%	6.0%	0.001	7.3%	6.2%	0.12
Renal insufficiency	195	6.4%	11.4%	<0.001	5.8%	10.4%	<0.001	7.9%	12.6%	<0.001
Hemodialysis	0	4.0%	1.1%	<0.001	3.7%	1.2%	<0.001	4.7%	0.9%	<0.001
Hypertension	73	69.5%	74.3%	<0.001	69.0%	72.8%	<0.001	70.7%	76.1%	<0.001
Diabetes mellitus	76	39.2%	31.0%	<0.001	36.5%	27.6%	<0.001	46.6%	35.5%	<0.001
Hyperlipidemia	87	51.3%	61.5%	<0.001	50.2%	62.1%	<0.001	54.4%	60.8%	<0.001
Family history of coronary artery disease	537	15.7%	33.9%	<0.001	15.4%	34.5%	<0.001	16.6%	33.1%	<0.001
Smoking	238	52.9%	46.0%	<0.001	52.5%	44.7%	<0.001	54.1%	47.7%	<0.001

Methods

The Coronary Revascularization Demonstrating Outcome database in Kyoto (CREDO-Kyoto) was a multicenter (n = 29) registry maintained in Kyoto, Japan. The Texas Heart Institute Research Database (THIRDBase) is an ongoing single-center registry maintained at the Texas Heart Institute in Houston, Texas. Details concerning the design of the CREDO-Kyoto and THIRDBase have previously been reported.[5,6] Both of these comprehensive, longitudinal, clinical registries of patients undergoing coronary revascularization procedures were designed to evaluate associated periprocedural and late events. CREDO-Kyoto enrolled patients from 2000 to 2002, and the THIRDBase has been a continuous, on-going registry since 1993. For the present analysis, we included only those THIRDBase patients enrolled from 1999 to 2003, to match the total number of patients in the CREDO-Kyoto registry. In both countries, all the study patients had undergone initial, elective, isolated revascularization procedures. All PCI patients had undergone placement of a bare metal stent (drug-eluting stents were not available for this use during the study period). The patients were excluded if they had undergone previous PCI or CABG, required valve surgery or peripheral vascular revascularization, or were undergoing primary PCI for an acute myocardial infarction (MI).

The baseline data regarding the patients' clinical characteristics were obtained prospectively from both registries. The coronary anatomic and procedural characteristics, in-hospital outcomes, and vital status as of December 31, 2006 were assessed for all patients. For the THIRDBase, survivorship was determined from the US Department of Vital Statistics Database. For CREDO-Kyoto, the follow-up data were obtained from hospital charts or by interviewing the patients or referring physicians. Both registries had remarkably high follow-up completion rates (THIRDBase 100%; CREDO-Kyoto 98% at 1 year and 95% at 2 years). The survival analyses included both in-hospital and long-term survival data, and these survival rates were not considered separately.

Each patient's history was obtained by interview when the patient arrived at the hospital or clinic, and the details were entered prospectively into the database. The following variables were documented: left ventricular ejection fraction, number of diseased vessels, urgency of the revascularization procedure, presence of hypertension (characterized by blood pressure of >130/90 mm Hg or the current use of antihypertensive medications), severity of angina (Canadian Cardiovascular Society classification), severity of congestive heart failure (New York Heart Association functional status), family history of CAD, previous MI, renal function, need for hemodialysis, presence of diabetes mellitus (characterized by a fasting blood sugar level of >6.87 mmol/L or the use of antidiabetic agents), and the presence of peripheral vascular disease (occlusive or aneurismal vascular disease in the aorta or other peripheral vessels).

The institutional review board of THIRDBase approved the present study. All enrollees provided written informed consent at hospital admission. All analyzed data were stripped of personal identifiers. For CREDO-Kyoto, owing to the retrospective nature of enrollment, the patients had not provided written informed consent; however, when later interviewed for the follow-up evaluation, 73 patients were excluded from the analysis because of their refusal to par-

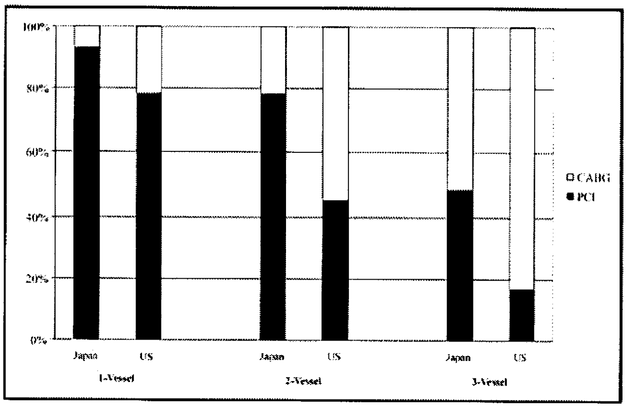


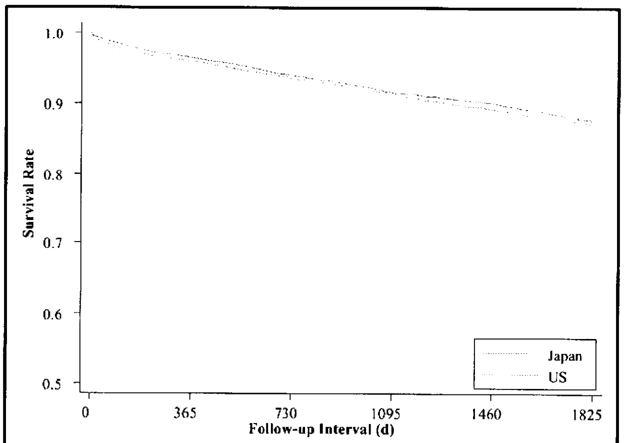
Figure 1. Proportion of PCI and CABG procedures according to number of diseased vessels.

ticipate in the study. This process was concordant with the guidelines for epidemiologic studies issued by the Ministry of Health, Labor, and Welfare of Japan.

To compare the 2 registries, we assessed the demographic characteristics and in-hospital mortality, using Pearson's chi-square test for discrete variables and Student's *t* test for continuous variables. We then used the Kaplan-Meier method to draw the survival curve and the log-rank test to identify significant differences in the unadjusted survival rates. We also compared the 2 registries with respect to the survival rates among the subgroups of patients undergoing PCI versus CABG. Logistic regression analysis and Cox proportional hazards models were used to examine the differences in demographic and clinical characteristics with regard to short- and long-term survival, respectively. Multivariate analyses were performed to control for possible confounding factors affecting the association between the registry and outcomes. The variables included in the multivariate models were age ≤65 years, gender, obesity, procedure type (PCI or CABG), history of MI, heart failure, New York Heart Association functional class, peripheral vascular disease, renal function, hemodialysis, hypertension, diabetes, hyperlipidemia, family history of CAD, smoking, the number of diseased vessels, and the geographic location of the registry. Renal function was characterized by a serum creatinine level of ≤179 μmol/L, a serum creatinine level of >179 μmol/L without hemodialysis, and a serum creatinine level of >179 μmol/L with hemodialysis. Cerebrovascular disease was excluded from the multivariate analyses because of differences in the definition of such disease by the 2 registries. To assess the validity of the proportional hazards assumption, we plotted −log [−log(survival)] curves for each category of nominal or ordinal covariates versus the log (analysis time). Because the proportional hazards assumption did not hold for the mode of coronary revascularization, the stratified Cox proportional hazards model using the revascularization procedure selected as the stratification variable was applied for the analysis of the long-term outcomes. Separate models were generated for the subgroups of patients with a high-risk profile (e.g., age ≥65 years, male gender, obesity, hemodialysis, diabetes, and a greater number of diseased vessels). The modeling procedure was performed for the cases for which the necessary data were available (complete case analysis) using Stata, version 10.1, software (StataCorp, College Station, Texas). All tests of significance were 2 tailed, and p values of <0.05 were considered significant.

Table 2
Risk of in-hospital mortality according to multivariable logistic regression analysis

Variable	Odds Ratio	95% Confidence Interval
Age ≥65 years	2.31	1.53–3.51
Women	1.24	0.83–1.85
Body mass index ≥25 kg/m^2	0.78	0.51–1.18
Coronary artery bypass grafting	3.90	2.53–6.03
Previous myocardial infarction	1.48	1.04–2.13
History of heart failure	2.14	1.43–3.21
New York Heart Association functional class IV	1.13	0.61–2.10
Peripheral vascular disease	1.75	1.19–2.57
Renal function		
Serum creatinine ≤179 μmol/L	1.00	—
Serum creatinine >179 μmol/L	2.97	1.85–4.77
Hemodialysis	5.46	3.10–9.63
Hypertension	1.16	0.75–1.80
Diabetes mellitus	1.50	1.04–2.16
Hyperlipidemia	0.65	0.45–0.93
Family history of coronary artery disease	1.00	0.64–1.56
Smoking	1.56	1.07–2.29
No. of diseased vessels		
1 Vessel	1.00	—
2 Vessels	1.47	0.86–2.51
3 Vessels	1.82	1.05–3.15
United States patients	1.31	0.82–2.08

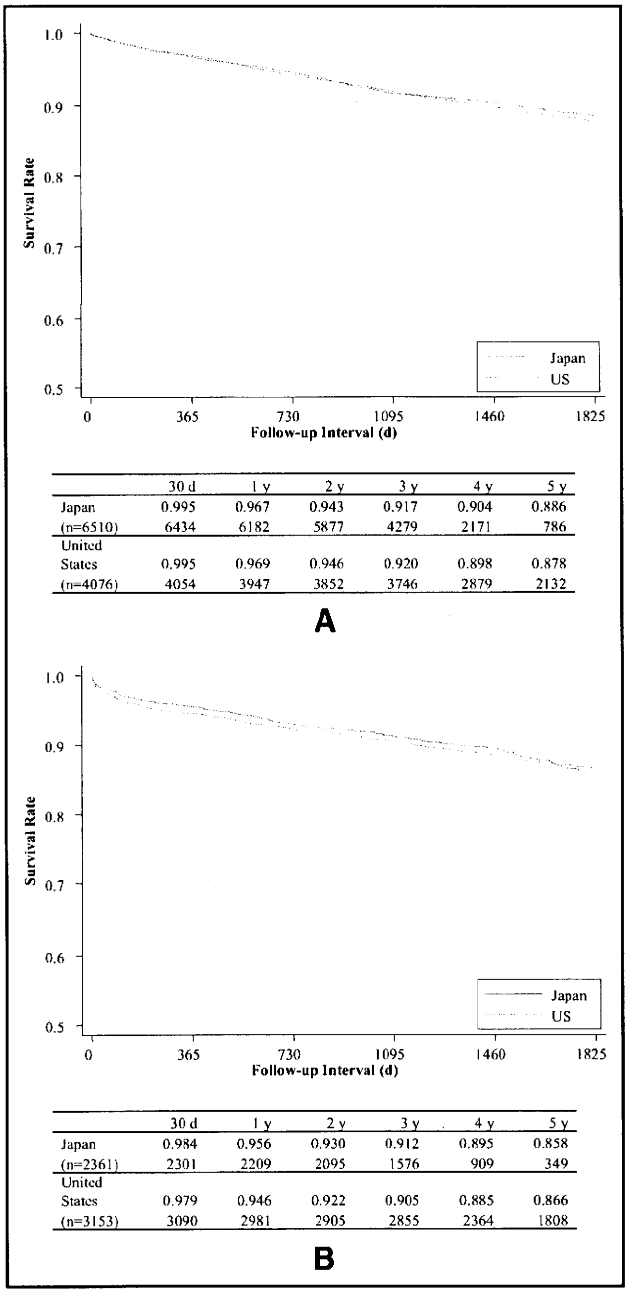


	30 d	1 y	2 y	3 y	4 y	5 y
Japan	0.992	0.964	0.939	0.916	0.901	0.877
(n=8871)	8734	8389	7971	5855	3080	1135
United States	0.988	0.959	0.935	0.913	0.893	0.873
(n=7229)	7143	6928	6756	6599	5243	3940

Figure 2. Kaplan-Meier survival curve for all patients (log-rank test, p = 0.35).

Results

The series included 16,100 patients—8,871 patients from the CREDO-Kyoto registry (median follow-up period



	30 d	1 y	2 y	3 y	4 y	5 y
Japan	0.995	0.967	0.943	0.917	0.904	0.886
(n=6510)	6434	6182	5877	4279	2171	786
United States	0.995	0.969	0.946	0.920	0.898	0.878
(n=4076)	4054	3947	3852	3746	2879	2132

	30 d	1 y	2 y	3 y	4 y	5 y
Japan	0.984	0.956	0.930	0.912	0.895	0.858
(n=2361)	2301	2209	2095	1576	909	349
United States	0.979	0.946	0.922	0.905	0.885	0.866
(n=3153)	3090	2981	2905	2855	2364	1808

Figure 3. Kaplan-Meier survival curves for PCI and CABG subgroups. *(A)* PCI subgroup (log-rank test, p = 0.53). *(B)* CABG subgroup (log-rank test, p = 0.95).

3.5 years, interquartile range 2.6 to 4.3) and 7,229 patients from the THIRDBase registry (median follow-up period 5.2 years, interquartile range 3.8 to 6.5). The Japanese patients were older and were more likely to be smokers and to have diabetes mellitus and cerebrovascular disease (Table 1). The US patients were more obese, with a greater body mass index. In general, the US patients had a greater prevalence of MI, renal insufficiency, and hypertension. Multivessel disease was seen more frequently in the Japanese patients than in the US patients.

The foregoing trends were also seen when the PCI and CABG patients were analyzed separately (Table 1), except that the Japanese CABG patients had a greater prevalence of peripheral vascular disease. In Japan, the proportion of PCI versus CABG procedures did not differ among patients with single-vessel disease, but PCI was performed more frequently in patients with multivessel disease (Figure 1). To treating 3-vessel disease, CABG was preferred in the US (82.2%), but PCI and CABG were performed with a similar frequency in Japan (48.5% and 51.5%, respectively).

Table 3
Risk of long-term mortality for each registry according to univariate analysis using stratified Cox proportional hazards model with revascularization procedure as stratification variable

Variable	Japan		United States	
	HR	95% CI	HR	95% CI
Age ≥65 years	2.74	2.29–3.27	3.01	2.65–3.43
Women	1.04	0.90–1.20	1.43	1.26–1.63
Hypertension	1.09	0.94–1.27	1.77	1.51–2.08
Diabetes mellitus	1.39	1.22–1.59	1.78	1.57–2.02
Hyperlipidemia	0.59	0.51–0.67	0.61	0.54–0.69
Family history of coronary artery disease	0.66	0.53–0.82	0.65	0.56–0.74
Smoking	0.91	0.80–1.05	1.08	0.96–1.22
Body mass index ≥25 kg/m^2	0.46	0.38–0.55	0.56	0.49–0.64
Previous myocardial infarction	1.45	1.26–1.67	1.36	1.21–1.54
History of heart failure	3.13	2.71–3.62	3.56	3.12–4.07
New York Heart Association class IV	3.17	2.25–4.46	2.96	2.50–3.50
Peripheral vascular disease	2.20	1.86–2.60	2.60	2.27–2.98
Cerebrovascular disease	1.78	1.52–2.07	2.42	1.98–2.97
Renal function				
Serum creatinine level ≤179 μmol/L	1.00	—	1.00	—
Serum creatinine level >179 μmol/L	6.98	5.54–8.78	2.68	2.30–3.13
Hemodialysis	6.12	5.07–7.40	8.83	6.68–11.7
No. of diseased vessels:				
1 Vessel	1.00	—	1.00	—
2 Vessels	1.48	1.23–1.78	1.22	1.04–1.43
3 Vessels	2.09	1.74–2.52	1.59	1.31–1.93
Left anterior descending artery disease	1.26	1.05–1.51	0.99	0.87–1.14
Left circumflex artery disease	1.43	1.23–1.65	1.30	1.14–1.49
Right coronary artery disease	1.59	1.37–1.85	1.21	1.06–1.37

CI, confidence interval; HR, hazard ratio.

Both registries had similar in-hospital outcomes, regardless of the revascularization procedure used. Overall, the in-hospital mortality rate was 0.9% for the Japanese patients and 1.1% for the US patients (p = 0.19), indicating that the procedural complication rates were similar between the 2 groups. When the in-hospital mortality rate was analyzed according to the revascularization procedure performed, it was similar for both PCI (0.45% in Japan vs 0.27% in the United Stages; p = 0.15) and CABG (2.2% in Japan vs 2.3% in the US; p = 0.99). Table 2 lists the multivariate predictors of in-hospital outcome. When the results were adjusted for these confounding variables, the US patients had a greater risk of in-hospital death compared to the Japanese patients (odds ratio 1.60, 95% confidence interval 1.02 to 2.51; p = 0.039).

The crude long-term mortality rate was similar in both Japan and the US (27.7 vs 28.2/1,000 person-years, respec-

Table 4
Risk of long-term mortality according to multivariate analysis

Variable	HR	95% CI
Age ≥65 years	2.65	2.36–2.99
Women	1.06	0.94–1.18
Body mass index ≥25 kg/m^2	0.68	0.60–0.76
Previous myocardial infarction	1.18	1.06–1.31
History of heart failure	2.07	1.83–2.35
New York Heart Association class IV	1.21	1.01–1.46
Peripheral vascular disease	1.54	1.37–1.74
Renal function		
Serum creatinine ≤179 μmol/L	1.00	—
Serum creatinine >179 μmol/L	2.28	1.97–2.65
Hemodialysis	5.20	4.36–6.20
Hypertension	1.23	1.09–1.39
Diabetes mellitus	1.35	1.22–1.50
Hyperlipidemia	0.72	0.65–0.80
Family history of coronary artery disease	0.86	0.76–0.97
Smoking	1.17	1.05–1.30
No. of diseased vessels:		
1 Vessel	1.00	—
2 Vessels	1.14	1.01–1.29
3 Vessels	1.43	1.24–1.64
United States patients	1.71	1.50–1.95

Abbreviations as in Table 3.

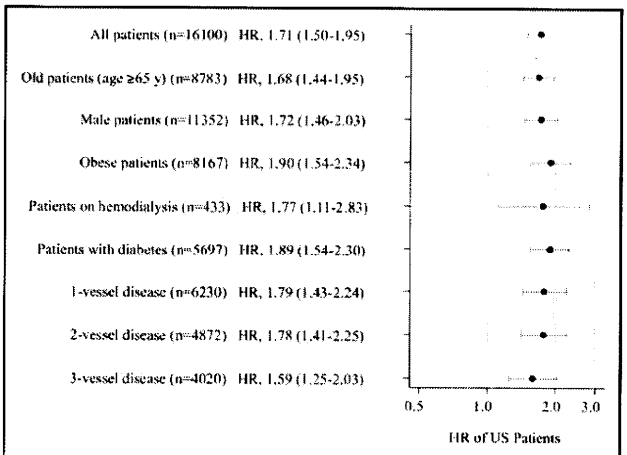


Figure 4. Multivariate analysis with hazard ratio and 95% confidence intervals for long-term mortality in US versus Japanese patients according to patient subgroup.

tively). Figure 2 shows the Kaplan-Meier survival curves for each registry. The crude hazard ratio for the American patients was 1.02 (95% confidence interval 0.93 to 1.13; $p = 0.65$). This trend did not alter when survival was analyzed according to revascularization procedure (Figure 3).

Several significant predictors of mortality were identified (Table 3). The univariate model showed that the strongest predictors of mortality ($p < 0.001$) in the Japanese group were age >65 years, body mass index >25 kg/m^2, a history of heart failure, the need for hemodialysis, and the presence of left circumflex artery disease. In the US group, the strongest predictors of mortality were age >65 years and variables associated with an atherosclerotic process, such as a history of MI, a history of heart failure, peripheral vascular disease, renal function, hemodialysis, hypertension, diabetes mellitus, hyperlipidemia, and a family history of CAD.

When the long-term mortality was adjusted for age and gender, the US patients had a significantly greater risk than the Japanese patients (hazard ratio 1.27, 95% confidence interval 1.15 to 1.40; $p < 0.001$). Additional adjustment, using the other long-term predictors listed in the "Methods" section, revealed comparable results (hazard ratio 1.71, 95% confidence interval 1.50 to 1.95; $p < 0.001$; Table 4). A similar trend was seen in all the high-risk subgroups (eg, age ≥65 years, male gender, obesity, use of hemodialysis, diabetes mellitus, multivessel disease; Figure 4).

Discussion

We used information from 2 well-established registries, CREDO-Kyoto and THIRDBase, to compare the clinical characteristics and outcomes of patients undergoing coronary revascularization in Japan versus the US. The present study involved a large number of patients (>8,000), a high rate of clinical follow-up observation, and an excellent database infrastructure and support system. Although the long-term outcomes were similar with regard to crude mortality, they appeared to favor the Japanese patients after the results were adjusted for confounding factors, including age, gender, and atherosclerotic risk factors.

The 2 registries differed greatly with respect to patient clinical backgrounds. The Japanese patients were older, more likely to be smokers, and more likely to have diabetes mellitus. In contrast, the American patients were more obese and had a greater prevalence of atherosclerotic processes such as MI, peripheral vascular disease, renal insufficiency, and hypertension. This finding agrees with the results of a previous study that compared the risk factors for atherosclerosis among patients of different racial backgrounds.[7,8]

Although smoking is decreasing in the Asian population, this habit remains significantly more prevalent in Japan than in Western countries. The greater prevalence of diabetes mellitus in Japanese patients is in accordance with the rates of this disease recorded by other CAD registries in Japan.[9] However, the adverse cardiovascular events (eg, cardiovascular death or MI) remained extremely low in Japanese patients with diabetes, as shown by our subgroup analysis. In the recent Japanese Primary Prevention of Atherosclerosis with Aspirin for Diabetes (JPAD) study, in which 2,539 patients were followed up for 4.3 years, the overall atherosclerotic event rate in the nonaspirin group was only 17.0/1,000 person-years.[10] In the Western population, patients who have both CAD and diabetes have a poor long-term outcome, especially when multiple vessels are involved.

Our results agree with those from other registries, which have shown a difference in the incidence of CAD-related clinical events among patients living in different countries, highlighting the greater mortality rates in North American populations and lower mortality rates in the Japanese and Chinese populations.[11] The reasons for these differences are not clear. The Japanese lifestyle, especially the daily diet, is now fairly close to that of Europe and the US. However, a number of dietary differences remain—such as a high intake of fish and salt (Japan) versus red meat and sugar (US).

Moreover, patients in Japan versus the US vary considerably with regard to their degree of mixed racial backgrounds, education, workload, and access to medical facilities, and the 2 countries have considerably different social systems. A recent survey of Japanese rural and urban areas showed a decreasing CAD rate despite widespread pursuit of a Western lifestyle; the CAD-related mortality rate has remained approximately ¼ of that encountered in the US.[12] The incidence of CAD in urban men is 100/100,000 in Japan versus 272 to 491/100,000 in the US.[13,14] The better prognosis in Japanese patients has been attributed to differences in the pathogenesis of acute coronary syndromes. Moreover, we speculate that, in Japanese patients, the coronary lesion remains stable after treatment (this was true even in the bare metal stent era) and that atherosclerotic risk factors such as obesity, peripheral vascular disease, and renal failure, which were more prevalent in US patients, contributed more to late mortality than did age.

Given the technical success of PCI and CABG, the focus is now on the optimal use of these techniques to improve survival and reduce symptomatic heart disease. For the best patient care, the interventional cardiologist or cardiothoracic surgeon must be able to predict outcomes, including long-term mortality, and thus define the risks and benefits of revascularization procedures for specific patients. It has increasingly been recognized that nonangiographic variables are more important than angiographic variables in predicting long-term outcomes.[15] Currently, long-term mortality is largely predicted by clinical variables such as age and the presence of congestive heart failure. These variables have been combined into risk scores[3,4]; however, none of these risk scores has directly included ethnic background information. In the Japanese population, postprocedural mortality is significantly low, such as was shown in the present study, and risk–prediction models might not be directly applicable. Our results have also indicated that these predictors differ significantly between the 2 countries, and ethnic information might play a crucial role in predicting the long-term mortality of patients with CAD. Future research involving large-scale registries or clinical studies must take account of differences in outcomes between different regions in the world.

Our study was limited because statistical adjustments were made only for the characteristics that were obtainable from both registries. Conditions such as cerebrovascular disease, unstable angina, and chronic obstructive pulmonary disease were excluded from the multivariate analyses because of considerable differences in the definition of such diseases. In addition, more subtle, immeasurable variables were not taken into account. These variables included differences in physician attitudes and approaches to diagnosis, health policies, and social and cultural circumstances. Some of these factors could have had a substantial effect. However, we attempted to nullify the effects of potential confounding variables using a Cox proportional hazards regression model.

Another limitation of our study was that technologic advances could quickly outdate our findings. One such advance was the advent of drug-eluting stents, which dramatically reduced the need for repeat revascularization after stent placement. No clear-cut evidence, however, has yet shown that such stents improve survival.[16] Therefore, we can still draw valid inferences about comparative survival from populations that have bare metal stents.

Finally, other outcome variables such as major adverse cardiac events and cerebrovascular events were not assessed in THIRDBase; thus, our assessment of long-term outcomes was based solely on mortality. The ascertainment of mortality was also different in the 2 registries, and the median follow-up period differed significantly (Japan 3.5 years vs US 5.2 years; Wilcoxon rank sum test $p < 0.001$).

Acknowledgment: The authors thank Virginia Fairchild, MB, of the Texas Heart Institute Department of Scientific Publications, for editorial assistance in preparing this report.

Supplementary Data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.amjcard.2010.01.349.

1. Carulli L, Rondinella S, Lombardini S, Canedi I, Loria P, Carulli N. Review article: diabetes, genetics and ethnicity. *Aliment Pharmacol Ther* 2005;22(Suppl 2):16–19.
2. Health: United States 2005 with Chartbook on Trends in the Health of Americans. Washington, DC: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics, 2005:62–63.
3. Anderson HV, Shaw RE, Brindis RG, McKay CR, Klein LW, Krone RJ, Ho KK, Rumsfeld JS, Smith SC Jr, Weintraub WS. Risk-adjusted mortality analysis of percutaneous coronary interventions by American College of Cardiology/American Heart Association guidelines recommendations. *Am J Cardiol* 2007;99:189–196.
4. Singh M, Gersh BJ, Li S, Rumsfeld JS, Spertus JA, O'Brien SM, Suri RM, Peterson ED. Mayo Clinic risk score for percutaneous coronary intervention predicts in-hospital mortality in patients undergoing coronary artery bypass graft surgery. *Circulation* 2008; 117:356–362.
5. Kimura T, Morimoto T, Furukawa Y, Nakagawa Y, Shizuta S, Ehara N, Taniguchi R, Doi T, Nishiyama K, Ozasa N, Saito N, Hoshino K, Mitsuoka H, Abe M, Toma M, Tamura T, Haruna Y, Imai Y, Teramukai S, Fukushima M, Kita T. Long-term outcomes of coronary-artery bypass graft surgery versus percutaneous coronary intervention for multivessel coronary artery disease in the bare-metal stent era. *Circulation* 2008;118:S199–S209.
6. Kohsaka S, Goto M, Virani S, Lee VV, Aoki N, Elayda MA, Reul RM, Wilson JM. Long-term clinical outcome of coronary artery stenting or coronary artery bypass grafting in patients with multiple-vessel disease. *J Thorac Cardiovasc Surg* 2008;136:500–506.
7. Hutchinson RG, Watson RL, Davis CE, Barnes R, Brown S, Romm F, Spencer JM, Tyroler HA, Wu K. Racial differences in risk factors for atherosclerosis: the ARIC study. Atherosclerosis Risk in Communities. *Angiology* 1997;48:279–290.
8. Kronmal RA, McClelland RL, Detrano R, Shea S, Lima JA, Cushman M, Bild DE, Burke GL. Risk factors for the progression of coronary artery calcification in asymptomatic subjects: results from the Multi-Ethnic Study of Atherosclerosis (MESA). *Circulation* 2007;115:2722–2230.
9. Motomura N, Miyata H, Tsukihara H, Okada M, Takamoto S. First report on 30-day and operative mortality in risk model of isolated coronary artery bypass grafting in Japan. *Ann Thorac Surg* 2008;86: 1866–1872.

10. Ogawa H, Nakayama M, Morimoto T, Uemura S, Kanauchi M, Doi N, Jinnouchi H, Sugiyama S, Saito Y; Japanese Primary Prevention of Atherosclerosis With Aspirin for Diabetes (JPAD) Trial Investigators. Low-dose aspirin for primary prevention of atherosclerotic events in patients with type 2 diabetes: a randomized controlled trial. *JAMA* 2008;300:2134–2141.
11. Tunstall-Pedoe H, Kuulasmaa K, Amouyel P, Arveiler D, Rajakangas AM, Pajak A. Myocardial infarction and coronary deaths in the World Health Organization MONICA project: registration procedures, event rates, and case-fatality rates in 38 populations from 21 countries in four continents. *Circulation* 1994;90:583–612.
12. Statistics and Information Department MsS, Ministry of Health, Labour and welfare. Vital Statistics of Japan 2003 (vol. 1) [Japanese]. Tokyo: Health and Welfare Statistics Association, 2005:1–358.
13. McGovern PG, Jacobs DR Jr, Shahar E, Arnett DK, Folsom AR, Blackburn H, Luepker RV. Trends in acute coronary heart disease mortality, morbidity, and medical care from 1985 through 1997: the Minnesota heart survey. *Circulation* 2001;104:19–24.
14. Rosamond WD, Folsom AR, Chambless LE, Wang CH. Coronary heart disease trends in four United States communities: the Atherosclerosis Risk in Communities (ARIC) study 1987–1996. *Int J Epidemiol* 2001;30(Suppl 1):S17–S22.
15. Cavender MA, Ohman EM. What do you need to know before performing a percutaneous coronary intervention? *Circulation* 2008;118: 609–611.
16. Malenka DJ, Kaplan AV, Lucas FL, Sharp SM, Skinner JS. Outcomes following coronary stenting in the era of bare-metal vs the era of drug-eluting stents. *JAMA* 2008;299:2868–2876.

Increased Graft Occlusion or String Sign in Composite Arterial Grafting for Mildly Stenosed Target Vessels

Susumu Manabe, MD, Toshihiro Fukui, MD, Tomoki Shimokawa, MD, Minoru Tabata, MD, Yuzo Katayama, MD, Satoshi Morita, MD, PhD, and Shuichiro Takanashi, MD

Department of Cardiovascular Surgery, Sakakibara Heart Institute, and Department of Biostatistics and Epidemiology, Yokohama City University, Tokyo, Japan

Background. Composite grafting is a useful technique that avoids the need for aortic manipulation and enables a wide range of target vessels to be revascularized, effectively using the limited arterial grafts available. However, it has not been clarified whether composite grafting can achieve angiographic outcomes equivalent to those obtained with individual grafting for specific target vessels.

Methods. We retrospectively reviewed 830 distal arterial graft anastomoses in 256 patients who underwent off-pump coronary artery bypass surgery and also underwent 1-year follow-up coronary angiograms. Four hundred and ten anastomoses using a composite grafting technique were compared with 420 anastomoses using individual grafting.

Results. In target vessels with mild stenosis, the incidence of graft occlusion or string sign was significantly higher in composite internal thoracic arteries (ITA) than in individual ITA grafts (composite 20.3% versus individual 7.3%; $p = 0.018$) and showed a higher tendency in composite radial arteries (RA) than in individual RA grafts (59.3% versus 36.4%, $p = 0.09$). In contrast, the incidence was similar between composite and individual ITA grafts (5.7% versus 3.3%, $p = 0.278$) and composite and individual RA grafts (11.5% versus 29.6%, $p = 0.297$) in target vessels with severe stenosis.

Conclusions. The angiographic outcomes of composite grafts were closely related to the severity of stenosis of the target coronary artery. In target vessels with mild stenosis, composite grafting resulted in a higher incidence of graft occlusion or string sign than individual grafting did.

(Ann Thorac Surg 2010;89:683–8)

Modern coronary artery bypass graft surgery (CABG) involves several sophisticated procedures developed to handle particular problems or improve the quality of treatment. The aortic "no-touch" technique is considered effective for reducing stroke risk in patients with the atherosclerotic ascending aorta, and multiple arterial grafting is usually preferred because it provides excellent long-term clinical outcomes. Composite grafting plays a crucial role in these procedures, because it eliminates the need for proximal anastomosis to the ascending aorta and conserves extra lengths of an arterial graft for additional grafting.

Although the prevalence of composite grafting is increasing, there have been few studies to support the feasibility of performing composite grafting for a particular target coronary artery. Several studies reported that the clinical and angiographic results of composite grafting were equivalent to those of individual grafting [1–3]. Conversely, some other studies reported that composite grafting may be susceptible to the detrimental effect of flow competition with native coronary artery when used for a mildly stenosed target vessel [4, 5]. The difference in angiographic outcomes between composite and individual grafting in target vessels with mild stenosis has not been clarified. Hence, the purpose of this study was to compare the angiographic outcomes between composite and individual grafts according to the severity of stenosis of the target coronary artery.

Material and Methods

Study Design

This was a retrospective cohort study to verify the hypothesis that angiographic outcomes of composite grafts

Accepted for publication Nov 19, 2009.

Address correspondence to Dr Manabe, Department of Cardiovascular Surgery, Sakakibara Heart Institute, Asahicho 3-16-1, Fuchu, Tokyo 183-0003, Japan; e-mail: s-manabe@fb3.so-net.ne.jp.

Published by Elsevier Inc

0003-4975/10/$36.00
doi:10.1016/j.athoracsur.2009.11.053

Table 1. Patient Characteristics

	Total n = 256	Without Composite n = 108	With Composite n = 148	*p* Value*
Age, years	66.3 ± 8.1	66.3 ± 8.1	66.6 ± 7.3	0.776
Male (n)	85.6% (219)	85.2% (92)	85.8% (127)	1.000
Coronary risk factor (n)				
Hypertension	69.9% (179)	69.4% (75)	70.3% (104)	0.891
Diabetes mellitus	41.0% (105)	35.2% (38)	45.3% (67)	0.123
Hyperlipidemia	63.7% (163)	68.5% (74)	60.1% (89)	0.189
Smoking	57.0% (146)	57.4% (62)	56.8% (84)	1.000
Old cerebral infarction (n)	7.4% (19)	4.6% (5)	9.5% (14)	0.227
PVD (n)	6.3% (16)	3.7% (4)	8.1% (12)	0.194
Chronic hemodialysis (n)	3.5% (9)	1.9% (2)	4.7% (7)	0.310

* Comparison between patients with and without composite grafts.

PVD = peripheral vascular disease.

were inferior to those of individual grafts in target vessels with mild stenosis. One-year angiographic outcomes of arterial grafts were reviewed, and incidence of graft occlusion or string sign was compared between composite and individual grafts according to the severity of stenosis of the target coronary artery. Moreover, multivariate analysis was performed to identify the independent predictor of graft occlusion or string sign. The Ethics Committee of Sakakibara Heart Institute approved this study, waived the need for patient consent, and provided approval before the publication of the data.

Study Subjects and Data Collection

Between September 2004 and July 2007, 536 patients underwent isolated CABG in our institute. All patients were scheduled for off-pump CABG. Six patients who were converted to an on-pump CABG were excluded from the study. We routinely performed coronary angiograms 1 year after surgery in patients who have undergone off-pump CABG, regardless of the patient's symptoms. Patients who died, refused angiographic evaluation, were more than 75 years old, or had renal dysfunction (serum creatinine > 1.2 mg/dL) were excluded from the angiographic follow-up. Of the 536 patients, 256 patients (47.8%) underwent 1-year follow-up angiograms and were retrospectively reviewed. Preoperative characteristics of the study patients are shown in Table 1.

In the 256 study patients, there were 1,050 distal anastomoses, an average of 4.1 per patient. Of these, 830 anastomoses were constructed with arterial grafts and 220 were constructed with saphenous vein. All composite grafts were constructed with arterial grafts. Anastomoses constructed with saphenous vein were excluded from the analysis. Among the 830 anastomoses using arterial grafts, 410 anastomoses were constructed with composite graft (composite group) and 420 anastomoses with individual graft (individual group). Both groups included sequential grafting. Graft material and location and stenosis of the target coronary artery are shown in Table 2. Composite grafts were made using an "I" configuration in 37 anastomoses and a "Y" configuration in 373 anastomoses.

One physician initially reviewed all the coronary angiograms, and a consensus was reached after review. For native coronary arteries, mild stenosis was defined as a stenotic lesion producing luminal narrowing of 75% or less, and severe stenosis as narrowing of more than 75%. Distal anastomoses were assessed and classified as patent, focally stenosed, string sign, or occluded. Focally stenosed was defined as a focal stenosis of 90% or greater anywhere within the conduit or at the anastomosis. String sign was defined as luminal narrowing throughout the entire conduit, including stenosis of 90% or more.

Operative Strategy

The surgical procedures and principles of off-pump CABG we used have been previously described [6]. The left-sided coronary arteries were revascularized with arterial grafts in most cases. The left anterior descending artery (LAD) was revascularized exclusively using the

Table 2. Graft Material and Location and Stenosis of Target Coronary Artery

	Composite n = 410	Individual n = 420	*p* Value
Graft material			<0.001
ITA	191 (46.6%)	336 (80.0%)	
RA	211 (51.5%)	49 (11.7%)	
GEA	8 (2.0%)	35 (8.3%)	
Location of target coronary artery			<0.001
LAD	34 (8.3%)	223 (53.1%)	
D	127 (31.0%)	51 (12.1%)	
LCX	234 (57.1%)	108 (25.7%)	
RCA	15 (3.7%)	38 (9.0%)	
Stenosis of target coronary artery			0.021
Mild, ≤ 75%	153 (37.3%)	125 (30.0%)	
Severe, > 75%	257 (62.7%)	295 (70.2%)	

D = diagonal branch; GEA = gastroepiploic artery; ITA = internal thoracic artery; LAD = left anterior descending coronary artery; LCX = left circumflex coronary artery; RA = radial artery; RCA = right coronary artery.

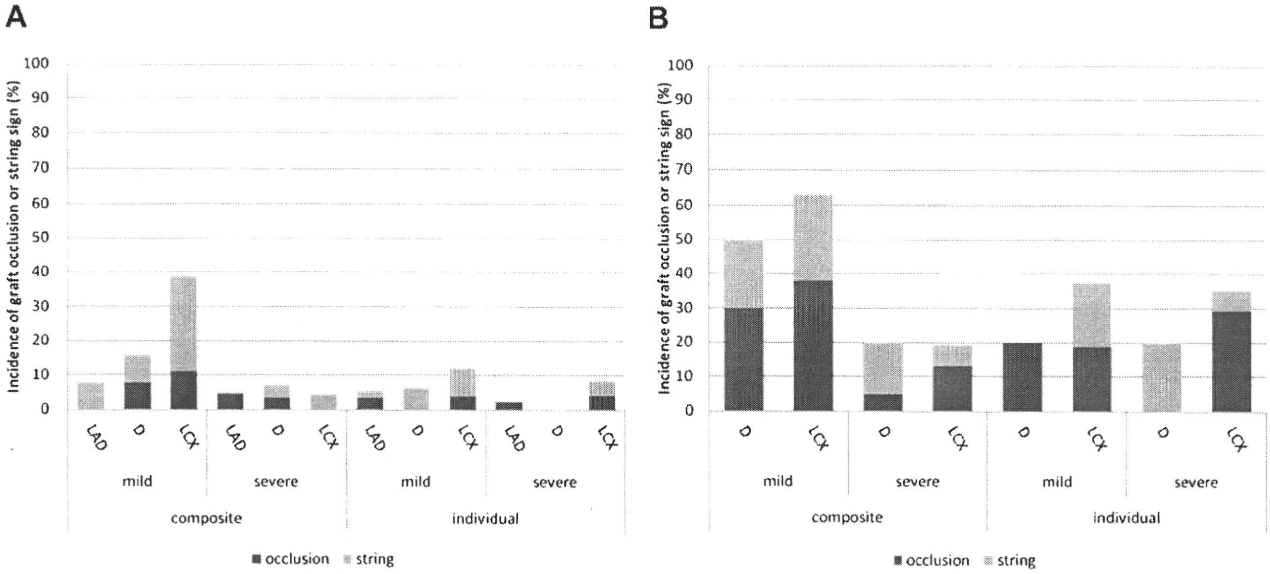


Fig 1. The incidence (%) of graft occlusion (dark gray shaded bar) or string sign (light gray shaded bar) according to graft material or location of target coronary artery. (A) internal thoracic artery (ITA). (B) Radial artery (RA). (D = diagonal artery; LAD = left anterior descending artery; LCX = left circumflex artery.)

internal thoracic artery (ITA), and the left ITA was preferably used. The right ITA was revascularized to the LAD only when the left ITA was required to bypass a remote anastomosis site of the left circumflex artery. The most frequently used arrangement for diagonal artery and left circumflex artery was composite grafting with right ITA and radial artery (RA). In this arrangement, the right ITA was used as an in-situ graft for the diagonal artery, and the RA was anastomosed proximally to the right ITA and distally to the left circumflex artery. The right coronary artery was grafted with saphenous vein or gastroepiploic artery in most cases. Use of the gastroepiploic artery was usually limited to patients with severe stenosis of the right coronary artery.

Statistical Analysis

Categorical variables are reported as percentages. To compare categorical variables, the χ^2 test was used to compare among three groups and the Fisher's exact test was used to compare between two groups. Student's t test was used to compare continuous variables. Multivariate analysis was performed to identify independent risk factors for graft occlusion or string sign. A generalized estimating equation method was used to account for within-patient correlation. Covariates included in the generalized estimating equation models were age, sex, hypertension, diabetes mellitus, hyperlipidemia, smoking history, peripheral vascular disease, graft material (ITA or non-ITA), target coronary artery (LAD or non-LAD), stenosis rate of target coronary artery (mild or severe), composite grafting, and sequential grafting. Odds ratios are presented with 95% confidence intervals. Statistical significance was accepted at p less than 0.05. All statistical analyses was performed with SPSS statistical software (SPSS version 17.0; SPSS Japan, Tokyo, Japan).

Results

Incidence of graft occlusion or string sign was compared between composite grafts and individual grafts according to graft material, location of target coronary artery, and stenosis of target coronary artery (Table 3). There were significant differences between composite and individual

Table 3. Incidence of Graft Occlusion or String Sign in Composite and Individual Grafts

	Composite	Individual	p Value
Graft material			
ITA	11.0% (21/191)	4.5% (15/336)	0.006
RA	34.6% (73/211)	32.7% (16/49)	0.868
GEA	12.5% (1/8)	22.9% (8/35)	1.000
Location of target coronary artery			
LAD	5.9% (2/34)	3.1% (7/223)	0.339
D	15.0% (19/127)	7.8% (4/51)	0.228
LCX	30.8% (72/234)	17.6% (19/108)	0.052
RCA	13.3% (2/15)	26.3% (10/38)	0.472
Stenosis of target coronary artery			
Mild, ≤ 75%	40.5% (62/153)	13.6% (17/125)	<0.001
Severe, > 75%	12.8% (33/257)	7.8% (23/295)	0.065
≤ 50%	66.7% (14/21)	57.1% (4/7)	0.674
> 50%, ≤ 75%	36.4% (48/132)	11.0% (13/118)	<0.001
> 75%, ≤ 90%	15.1% (23/152)	6.9% (13/188)	0.020
> 90%	9.5% (10/105)	9.3% (10/107)	1.000

D = diagonal branch; GEA = gastroepiploic artery; ITA = internal thoracic artery; LAD = left anterior descending coronary artery; LCX = left circumflex coronary artery; RA = radial artery; RCA = right coronary artery.

Table 4. Incidence of Graft Occlusion or String Sign According to Severity of Target Coronary Artery

	Composite	Individual	*p* Value
ITA			
Mild, ≤ 75%	20.3% (14/69)	7.3% (7/96)	0.018
Severe, > 75%	5.7% (7/122)	3.3% (8/240)	0.278
≤ 50%	14.3% (1/7)	60.0% (3/5)	0.222
> 50%, ≤ 75%	21.0% (13/62)	4.4% (4/91)	0.003
> 75%, ≤ 90%	5.6% (4/72)	3.2% (5/157)	0.473
> 90%	6.0% (3/50)	3.6% (3/83)	0.672
RA			
Mild, ≤ 75%	59.3% (48/81)	36.4% (8/22)	0.090
Severe, > 75%	11.5% (25/130)	29.6% (8/27)	0.297
≤ 50%	93.0% (13/14)	50.0% (1/2)	0.242
> 50%, ≤ 75%	50.7% (34/67)	35.0% (7/20)	0.308
> 75%, ≤ 90%	23.4% (18/77)	40.0% (6/15)	0.206
> 90%	13.2% (7/53)	16.7% (2/12)	0.667

ITA = internal thoracic artery; RA = radial artery.

grafts in ITA grafts and in the presence of mild stenosis of target coronary artery.

Incidence of graft occlusion or string sign in ITA and RA graft according to severity of target coronary artery is shown in Table 4. In target vessels with severe stenosis, there were no differences in the incidence of graft occlusion or string sign between composite and individual grafts in ITA (composite 5.7% versus individual 3.3%, $p = 0.278$) and RA (11.5% versus 29.6%, $p = 297$). But in target vessels with mild stenosis, the incidence of graft occlusion or string sign was significantly higher for composite grafts than for individual grafts in ITA (20.3% versus 7.3%, $p = 0.018$) and showed a lower tendency in RA (59.3% versus 36.4%, $p = 0.09$). The incidence of graft occlusion or string sign according to graft material, location and stenosis of the target coronary artery, and graft configuration is shown in Figure 1. The incidences of graft occlusion and string sign were particularly high when composite grafts were used for a mildly stenosed target vessel, irrespective of the graft material or location of the target coronary artery.

The results of multivariate analysis are shown in Table 5. The independent predictors of graft occlusion or string sign in total were non-ITA graft, mild stenosis of the target coronary artery, and peripheral vascular disease. Composite grafting was an independent predictor of graft occlusion or string sign only when grafted to the target vessels with mild stenosis.

Comment

Comparison of Composite and Individual Grafting

The present study revealed that the angiographic outcomes of composite grafts were closely related to the severity of stenosis of the target coronary artery. Several previous studies reported that the patency rate of composite grafts was equal to that of individual grafts [1–3]. However, none of them examined the patency rate in relation to stenosis of the target coronary artery. Suboptimum angiographic results of composited grafting for mildly stenosed target vessels have been reported by several studies. Pevni and colleagues [4] reported that a lower stenosis rate of the target coronary arteries was associated with a higher occlusion rate of composite ITA grafts. Gaudino and associates [5] reported that the threshold of stenosis for graft occlusion in a target coronary artery was higher in composite RA grafts than in individual RA grafts. Nakajima and associates [7] reported that 75% stenosis in the right coronary artery was an independent predictor of competitive flow and graft occlusion. From a practical standpoint, whether there is a difference in angiographic outcomes between composite and individual grafts for particular target vessels has been considered important, but none of these studies compared angiographic outcomes of composite and individual grafting. The present study is the first to demonstrate a higher incidence of graft failure in composite grafting for mildly stenosed target vessels. Moreover, in target vessels with mild stenosis, composite grafting has been shown to be an independent predictor of graft occlusion or string sign. Based on these results, we do not recommend composite grafting in target vessels with mild stenosis.

Mechanism of Graft Failure in Composite Grafts

The precise mechanism of graft failure in composite grafts has not been completely clarified. Arterial grafts are known to narrow diffusely or occlude when they are used in low-flow conditions [6, 8]. The susceptibility of composite grafting to low-flow conditions when used in target vessels with mild stenosis has been suggested by several studies. Studies examining the blood flow of composite grafts reported flow reduction of approximately 20% for composite grafting compared with the

Table 5. Multivariate Analysis of Risk Factors for Graft Occlusion or String Sign

Risk Factors	Odds Ratio	95% CI	*p* Value
Total			
Non-ITA	4.88	2.74–8.69	<0.001
Mild stenosis	3.61	2.29–5.70	<0.001
Composite grafting	1.37	0.70–2.68	0.362
Peripheral vascular disease	2.65	1.21–5.82	0.015
For mildly stenosed target vessels			
Non-ITA	5.80	2.64–12.71	<0.001
Composite grafting	2.73	1.17–6.40	0.021
For severely stenosed target vessels			
Non-ITA	4.26	1.83–9.90	<0.001
Composite grafting	0.72	0.27–1.91	0.509
Peripheral vascular disease	4.55	1.69–12.23	0.003

CI = confidence interval; ITA = internal thoracic artery.

sum of 2 individual grafts [9, 10]. Furthermore, the flow through a composite graft is strongly influenced by native coronary flow. Markwirth and colleagues [11] reported that in composite grafts anastomosed to a patent but stenosed target vessel, the graft flow is lower by 40% than that in grafts anastomosed to occluded target vessels. Nakajima and coworkers [7] reported the incidence of flow competition in composite grafts was as high as 14.6%. These findings suggest that composite grafting may be susceptible to the detrimental effect of flow competition with native coronary artery, resulting in a low-flow condition. This supposition is in agreement with the finding in the present study that mild stenosis of the target coronary artery is related to the incidence of graft occlusion or string sign in composite grafts.

Study Limitations

This study has several limitations. First, all data were retrospectively collected, which may have led to information bias. Second, a follow-up angiogram was performed in only 47.8% of the patients who underwent off-pump CABG during this study period. The angiogram was performed according to a protocol and was not symptom-directed. Third, composite grafting included both I and Y configurations. According to our data, there were no differences in patency rate between these configurations. Fourth, in some graft designs, the number of anastomoses was too small to perform statistical analysis. The number of gastroepiploic arteries was too small to draw any conclusion. The number of individual RA grafts was relatively small, which may have involved a wide variation of the data. Fifth, the graft occlusion and string sign may include intraoperative graft failure, because we did not perform early postoperative angiography in all patients.

In conclusion, the angiographic outcomes of composite grafts were closely related to the severity of stenosis of the target coronary artery. In target vessels with mild stenosis, angiographic outcomes of composite grafts were inferior to those of individual grafts.

References

1. Calafiore AM, Contini M, Vitolla G, et al. Bilateral internal thoracic artery grafting: long-term clinical and angiographic results of in situ versus Y grafts. J Thorac Cardiovasc Surg 2000;120:990–8.
2. Kim KB, Cho KR, Chang WI, Lim C, Ham BM, Kim YL. Bilateral skeletonized internal thoracic artery grafting in off-pump coronary artery bypass: early result of Y versus in situ grafts. Ann Thorac Surg 2002;74(Suppl):1371–6.
3. Fukui T, Takanashi S, Hosoda Y, Suehiro S. Total arterial myocardial revascularization using composite and sequential grafting with the off-pump technique. Ann Thorac Surg 2005;80:579–85.
4. Pevni S, Hertz I, Medalion B, et al. Angiographic evidence for reduced graft patency due to competitive flow in composite arterial T-grafts. J Thorac Cardiovasc Surg 2007;133: 1220–5.
5. Gaudino M, Alessandrini F, Pragliola C, et al. Effect of target artery location and severity of stenosis on mid-term patency of aorta-anastomosed radial artery grafts. Eur J Cardiothorac Surg 2004;25:424–8.
6. Fukui T, Takanashi S, Hosoda Y, Suehiro S. Early and midterm results of off-pump coronary artery bypass grafting. Ann Thorac Surg 2007;83:115–9.
7. Nakajima H, Kobayashi, J, Tagusari O, Bando K, Niwaya K, Kitamura S. Competitive flow in arterial composite grafts and effect of graft arrangement in off-pump coronary revascularization. Ann Thorac Surg 2004;78:481–6.
8. Tokuda Y, Song MH, Oshima H, Usui A, Ueda Y. Predicting midterm coronary artery bypass graft failure by intraoperative transit time flow measurement. Ann Thorac Surg 2008; 86:532–6.
9. Affleck DG, Barner HB, Bailey MS, et al. Flow dynamics of the internal thoracic and radial artery T-graft. Ann Thorac Surg 2004;78:1290–4.
10. Royse AG, Royse CF, Groves KL, Yu G. Blood flow in composite arterial grafts and effect of native coronary flow. Ann Thorac Surg 1999;68:1619–22.
11. Markwirth T, Hennen B, Scheller B, Schafers HJ, Wendler O. Flow wire measurements after complete arterial coronary revascularization with T-grafts. Ann Thorac Surg 2001;71: 788–93.

INVITED COMMENTARY

This report by Manabe and colleagues [1] provides a 1-year angiographic follow-up of coronary revascularization using composite grafting, which was compared with revascularization using individual grafting, and composite grafting in target vessels with mild stenosis is not recommended.

Greater freedom from reinterventions and enhanced long-term survival rates have been demonstrated when bilateral internal thoracic arteries (ITAs) are used rather than a single ITA graft in surgical revascularization for multi-vessel coronary disease. The superiority of one method in comparison to another has not been established for bilateral ITA grafting in an individual or composite configuration. A recent study by Kim and colleagues [2] demonstrated that perfusion improvements were similar for both bilateral individual ITA and composite grafts in terms of reversibility scores at 5 years postoperatively.

Revascularization of stenotic coronary lesions that induce myocardial ischemia can improve a patient's functional status and outcome. However, the benefit of revascularization is less clear for mildly stenotic coronary lesions that do not induce myocardial ischemia. Coronary angiography remains the most accurate morphologic assessment of lumen of the coronary arteries. However, angiographically, the degree of stenosis is a poor tool for gauging the functional significance of a specific coronary stenosis. Fractional flow reserve (ie, the ratio of maximal blood flow in a stenotic artery to normal maximal flow) is an index of the physiologic significance of a coronary stenosis, and this can easily be measured during coronary angiography. The combination of anatomic assessment and precise functional information is indispensable in tailoring the revascularization in angiographically dubious stenoses [3].

0003-4975/10/$36.00
doi:10.1016/j.athoracsur.2009.12.039

ACD

Angiographic outcomes of right internal thoracic artery grafts in situ or as free grafts in coronary artery bypass grafting

Toshihiro Fukui, MD, PhD,[a] Minoru Tabata, MD, MPH,[a] Susumu Manabe, MD, PhD,[a] Tomoki Shimokawa, MD, PhD,[a] Satoshi Morita, MD, PhD,[b] and Shuichiro Takanashi, MD[a]

Objective: We sought to compare early and 1-year angiographic results of various coronary artery bypass grafting configurations with the right internal thoracic artery in combination with the left internal thoracic artery.

Methods: We reviewed the records of 705 patients who underwent bilateral internal thoracic artery grafting between September 2004 and November 2008. The right internal thoracic artery was used as an in situ graft in 547 patients and as a free graft in 158 patients. We compared operative and postoperative variables and early and 1-year angiographic patency rates of the right internal thoracic artery between the groups.

Results: The operative mortality and incidence of postoperative complications were not significantly different between groups. The overall patency rates of the right internal thoracic artery were 98.8% at early angiography and 94.3% at 1-year postoperative follow-up. There were no significant differences in patency rate between in situ and free right internal thoracic artery grafts (98.6% vs 99.3% early and 95.3% vs 89.8% at 1 year). The best patency rate of the right internal thoracic artery was achieved with in situ grafting to the left anterior descending system (99.4% early and 98.5% at 1 year).

Conclusions: Patency rates of in situ and free right internal thoracic artery grafts were similar in early and 1-year angiographic studies. Among various configurations, the best patency of the right internal thoracic artery was obtained with in situ grafting to the left anterior descending coronary artery. (J Thorac Cardiovasc Surg 2010;139:868-73)

Internal thoracic artery (ITA) grafts are the most reliable conduits for revascularization of diseased coronary arteries because of their long-term durability.[1] The use of bilateral ITA grafts has been shown to provide better survival and economic benefits than the use of single ITA grafts.[2] Furthermore, the patency rate and survival benefits were satisfactory when bilateral ITAs were used for the left coronary system.[3] There are, however, many different arrangements of the bilateral ITA in left-sided myocardial revascularization. In particular, the right ITA has been flexibly used as an in situ or free graft in combination with an in situ left ITA.[4] An in situ right ITA can be used for anterior territory (the left anterior descending coronary artery [LAD] and diagonal branch) along the front of the ascending aorta or lateral territory (obtuse marginal or posterolateral branch) through the transverse sinus. A free right ITA can be used as a composite graft or aortocoronary bypass graft.[5]

There is little information available on angiographic studies comparing these various configurations with bilateral ITA grafting. The aim of this study was to examine the early and 1-year angiographic results of various strategies with right ITA grafts in combination with in situ left ITA grafts. Furthermore, we sought to evaluate the serial angiographic outcomes of right ITA grafts.

From the Department of Cardiovascular Surgery,[a] Sakakibara Heart Institute, Tokyo, Japan, and the Department of Biostatistics and Epidemiology,[b] Yokohama City University Medical Center, Yokohama, Japan.

Disclosures: None.

Received for publication March 9, 2009; revisions received May 1, 2009; accepted for publication May 31, 2009; available ahead of print July 27, 2009.

Address for reprints: Toshihiro Fukui, MD, Department of Cardiovascular Surgery, Sakakibara Heart Institute, 3-16-1 Asahi-cho, Fuchu City, Tokyo 183-0003, Japan (E-mail: tfukui-cvs@umin.ac.jp).

0022-5223/$36.00

doi:10.1016/j.jtcvs.2009.05.033

MATERIALS AND METHODS

Patient Population

Between September 2004 and November 2008, a total of 827 patients underwent isolated coronary artery bypass grafting at Sakakibara Heart Institute. Of these patients, 705 (85.2%) underwent bilateral ITA grafting. Preoperative characteristics of these 705 patients are shown in Table 1. We used bilateral ITA for patients who needed revascularization of both the LAD and left circumflex artery territories. The right ITA was used as an in situ graft in 547 patients (77.6%) and as a free graft in 158 patients (22.4%). Our grafting strategy of right ITA is described in Table 2. When the right ITA was used as an inflow of other grafts (radial artery or saphenous vein graft), an end-to-end anastomosis was performed between grafts. We applied multiple sequential grafting with the free right ITA in patients with a limited number of grafts. When we anastomosed the free right ITA to the ascending aorta, we routinely used intraoperative epiaortic echocardiography to detect a disease-free area of the aorta. When we anastomosed the free right ITA proximally to another graft (left ITA, radial artery, or saphenous vein graft), we created a Y-composite graft.

Operation

The operative technique used for off-pump coronary artery bypass grafting has been described previously.[6] All arterial grafts were harvested in a skeletonized fashion with an ultrasonic scalpel (Harmonic Scalpel; Ethicon Endosurgery, Cincinnati, Ohio). We bypassed all significantly diseased coronary vessels (at least 50% diameter reduction) larger than 1 mm in diameter. We performed long segmental reconstruction when the LAD was diffusely diseased and its branches, such as septal and diagonal arteries,

Abbreviations and Acronyms
ITA = internal thoracic artery
LAD = left anterior descending coronary artery

were affected by severe atheromatous plaques. An arteriotomy was extended proximally and distally to the intact segment of the LAD. Additionally, we performed endarterectomy when the atheromatous plaque was circumferential or too hard to pass a needle. The left ITA was anastomosed to the LAD in a long on-lay patch fashion with 7-0 and 8-0 polypropylene running sutures. The detailed indication, technique, and outcomes of long segmental reconstruction of the LAD have been described previously.[7] Although the sequential grafting to a proximal and a distal LAD could achieve the same objective, we prefer this method and have had excellent outcomes.[7]

Angiography

Early postoperative angiography was performed in 579 patients (82.1%) who gave us informed consent. Median time of early postoperative angiography was 10 days after surgery (range 1–20 days). If a patient had symptoms during follow-up, diagnostic angiography was performed at that time. For patients who did not have symptoms within 1 year after surgery, follow-up angiography was performed at 1 year. The follow-up postoperative angiography was performed for 336 patients (47.7%) at a median of 12.2 months after surgery (range 2–21 months). Of these patients, 312 patients (44.3%) underwent both early and 1-year angiographic studies.

We compared the preoperative, intraoperative, postoperative, and angiographic variables between patients with in situ right ITA grafts and those with free right ITA grafts. All data were collected prospectively and reviewed retrospectively. The institutional review board approved this retrospective study and waived the need for written consent.

Nonelective operations included both emergency and urgent cases according to the definition of the Society of Thoracic Surgeons database. Operative death was defined as death occurring within 30 days after surgery. Low-output syndrome was defined as the postoperative need for any dose of adrenaline or more than 5 $\mu g\ kg^{-1}\ min^{-1}$ of dopamine or dobutamine. Perioperative myocardial infarction was defined as a positive result for new Q waves in an electrocardiogram or a peak creatine kinase MB level of greater than 10% of total creatine kinase. Respiratory failure was defined as requirement for prolonged ventilation (>48 hours) or presence of pneumonia. A postoperative cerebrovascular accident was defined as a new stroke or intracranial bleeding and was confirmed by computed tomography. In patients with preoperative stroke, postoperative stroke was defined as a worsening of the neurologic deficit with new radiologic findings.

Patent graft was defined as a graft without occlusion, significant stenosis (>90%), or string sign. String sign was defined as luminal narrowing throughout the entire conduit, including stenosis of 90% or greater. Grafts with competitive flow or reverse flow were considered patent unless they had occlusion, significant stenosis, or string sign. Competitive flow and reverse flow were defined according to the classification by Nakajima and colleagues.[8] Competitive flow was defined as a situation in which the target vessel was barely opacified from the ITA graft injection and the bypass graft was filled by retrograde flow from the native coronary injection. Reverse flow was defined as a situation in which the distal anastomotic site was not opacified from the ITA graft injection at all but was filled clearly by retrograde flow from the native coronary injection.

Early and 1-year patency rates were calculated by dividing the number of patent grafts by the total number of grafts. If patients with early nonpatent grafts underwent 1-year angiography, those nonpatent grafts were also counted as 1-year nonpatent grafts.

Statistical Analysis

All statistical analyses were performed with StatView 5.0 software (SAS Institute Inc, Cary, NC). Continuous variables are reported as the mean ± SD if normally distributed. Otherwise, they are reported as median.

ACD

TABLE 1. Preoperative characteristics of patients with right internal thoracic artery as in situ or free graft

	All (n = 705)	In situ (n = 547)	Free (n = 158)	*P* value
Age (y, mean ± SD)	67.9 ± 9.4	68.2 ± 9.2	66.7 ± 10.0	.0837
Sex (no. female)	125 (17.7%)	90 (16.5%)	35 (22.2%)	.1250
Body surface area (m^2, mean ± SD)	1.7 ± 0.2	1.7 ± 0.2	1.6 ± 0.2	.0119
Unstable angina (no.)	225 (31.9%)	177 (32.4%)	48 (30.4%)	.7090
Canadian Cardiovascular Society class (mean ± SD)	2.2 ± 0.9	2.3 ± 0.9	2.2 ± 0.8	.5474
Ejection fraction (%, mean ± SD)	55.7 ± 12.1	55.8 ± 11.9	55.7 ± 12.3	.9380
Diseased vessels (mean ± SD)	2.8 ± 0.4	2.8 ± 0.4	2.9 ± 0.3	.0118
Left main disease (no.)	240 (34.0%)	190 (34.7%)	50 (31.6%)	.5309
Creatinine (mg/dL, mean ± SD)	1.2 ± 1.4	1.1 ± 1.2	1.4 ± 1.9	.0257
Congestive heart failure (no.)	95 (13.5%)	65 (11.9%)	30 (19.0%)	.0299
Previous myocardial infarction (no.)	344 (48.8%)	263 (48.1%)	81 (51.3%)	.5385
Hypertension (no.)	469 (66.5%)	365 (66.7%)	104 (65.8%)	.9071
Diabetes mellitus (no.)	341 (48.4%)	250 (45.7%)	91 (57.6%)	.0109
Insulin (no.)	79 (11.2%)	54 (9.9%)	25 (15.8%)	.0517
Hyperlipidemia (no.)	433 (61.4%)	337 (61.6%)	96 (60.8%)	.9199
Smoking (no.)	427 (60.6%)	327 (59.8%)	100 (63.3%)	.4820
Previous stroke (no.)	88 (12.5%)	64 (11.7%)	24 (15.2%)	.3018
Peripheral vascular disease (no.)	65 (9.2%)	45 (8.2%)	20 (12.7%)	.1235
Chronic obstructive pulmonary disease (no.)	28 (4.0%)	18 (3.3%)	10 (6.3%)	.1358
Nonelective (no.)	88 (12.5%)	81 (14.8%)	7 (4.4%)	.0003
Previous percutaneous coronary intervention (no.)	200 (28.4%)	152 (27.8%)	48 (30.4%)	.5916
Reoperation (no.)	9 (1.3%)	5 (0.9%)	4 (2.5%)	.1195

TABLE 2. Strategy for using either in situ or free right internal thoracic artery graft

Target	Reasons	No.
In situ		547
Left anterior descending artery	Unstable left main or bifurcation disease	124
Diagonal branch	Larger than other lateral vessels; inflow of radial artery graft as Y graft	262
Circumflex artery	Single major lateral vessel	128
Inflow for another graft	Diseased aorta	33
Free		158
Diagonal branch	Multiple grafting	26
Circumflex artery	Multiple grafting	132

Continuous variables were compared with the Student *t* test, whereas discrete variables were compared with the χ^2 test or Fisher exact test.

RESULTS

Clinical Outcomes

Preoperative characteristics of both groups are shown in Table 1. Mean body surface area was significantly larger in the in situ right ITA group than in the free right ITA group ($P = .0119$). The mean number of diseased vessels was significantly larger in the free right ITA group than in the in situ right ITA group ($P = .0118$). Preoperative creatinine levels were significantly higher in the free right ITA group than in the in situ right ITA group ($P = .0299$). The free right ITA group contained a significantly larger number of patients with histories of congestive heart failure and diabetes mellitus than did the in situ right ITA group ($P = .0299$ and $P = .0109$, respectively). More patients in the in situ right ITA group underwent emergency or urgent operations than in the free right ITA group ($P = .0003$).

Operative and postoperative variables are listed in Table 3. There was no significant difference in the mean number of distal anastomoses per patient between the groups ($P = .9290$). The number of distal anastomoses of the right ITA, however, was higher in the free ITA group than in the in situ ITA group ($P < .0001$).

Long segmental reconstruction of the LAD was carried out with the left ITA in 288 patients (40.9%). The operative time in the free right ITA group was significantly longer than that in the in situ right ITA group ($P = .0007$). The operative mortality was not significantly different between the groups ($P = 0.6569$). The incidence of postoperative complications was also not significantly different between the groups.

During the follow-up period, among the 705 patients there were 10 patients with recurrent angina, 12 with congestive heart failure, and 1 with stroke.

Angiographic Outcomes

The follow-up angiographic studies included patients without symptoms (n = 326) and those with symptoms (n = 10). Among the 10 patients with symptoms, percutaneous coronary intervention was performed in 5 cases. Of these 5 patients, 2 patients needed percutaneous coronary intervention for new coronary lesions. The other 3 patients needed percutaneous coronary intervention for stenosis of the gastroepiploic artery graft. Five patients who did not undergo percutaneous coronary intervention had stenosis of small native coronary arteries that were not an indication for intervention. None of these 10 patients were found to have a lesion related to the right ITA graft.

The overall patency rates of the right ITA were 98.8% at early angiography and 94.3% at 1-year angiography. The patency rates of the left ITA were 99.1% in the early study and 97.0% in the 1-year study. There were no significant differences in the early ($P = .7732$) and 1-year ($P = .1288$) patency rates between the left and right ITAs. Patency rates of various configurations of the right ITA at both early and 1-year angiographic studies are listed in Table 4.

In early examinations, there was no significant difference in the patency rate between in situ and free right ITAs ($p > .9999$). In the in situ right ITA group, the patency rate of the right ITA graft when used as an inflow to other grafts was significantly lower than when used as a direct graft to coronary arteries ($P = .0149$). In the free right ITA group, the site of proximal anastomoses (composite or aorta) did not affect the patency rate ($P > .9999$). In 1-year examinations, there was also no significant difference in the patency rate between in situ and free right ITAs ($P = .1792$). In the in situ right ITA group, the patency rate of the right ITA anastomosed to the anterior territory was superior to that of other grafting methods ($P < .0001$). In the free group, there was no significant difference in the patency rate between sites of proximal anastomoses ($P > .9999$).

When we compared the patency rates between the anterior and posterior routes in patients with in situ right ITA, there was no difference in early patency rate between these configurations ($P = .2735$). The 1-year patency rate of the anterior route, however, was superior to that of the posterior route ($P = .0042$).

Nonpatent right ITA grafts at any time are listed in Table 5. Among 21 nonpatent grafts, 16 grafts (76.1%) were anastomosed to the coronary artery with low stenosis rate (50%–75%).