Off Pump Coronary Artery Bypass Grafting in Patients with Left Ventricular Dysfunction

Kyung-Jong Yoo

Yonsei Cardiovascular Hospital

Yonsei University

Surgical Options of Ischemic Heart Failure

- Isolated CABG or *OPCAB*
- Heart transplantation
- Artificial Heart or Ventricular Assist Device
- Mitral valve repair
- Dynamic Cardiomyoplasty
- Left Ventricular Volume Reduction Surgery
- Cell Transplantation with or without bypass grafting

Surgical considerations in LV dysfunction

- **Completeness of revascularization**

  Complete versus incomplete

- **Graft selection for good perfusion and long-term patency**

  Vein versus Artery

- **Myocardial protection**

  On-Pump versus Off-Pump

Complete Revascularization

Comparison of complete and incomplete revascularization in CABG-patients with severely impaired LV function

U Boeken et al. Z Kardiol 2004;93:216-21

- **263 patients with LVEF ≤ 30%**
- **Definition of incomplete revascularization :**

  The difference between preoperatively estimated grafts and the number of grafted vessels
- **Group A (complete revascularization) : 158 patients**
- **Group B (incomplete revascularization) : 105 patients**

Table 1 a Intraoperative underlying reasons for incomplete revascularization in group B (ICR; n = 105)

Reason	Number of appearance	Portion (%)
Diffuse coronary artery disease	49	46.7
Massive sclerotic coronary vessel wall	38	36.2
Failure of exhibition of the coronary vessel	11	10.5
Coronary artery too small	12	11.4
Quality of (venous) graft too poor	8	7.6

Table 2 Intraoperative parameters in groups A (CR) and B (ICR)

	A	B	p
Op. in cardioplegia (*Bretschneider-solution*) (%)	61	59	n. s.
Number of grafts	3.59 ± 0.58	2.92 ± 0.47	< 0.05
Duration of surgery (min)	223 ± 21	207 ± 20	n. s.
Duration of ECC (min)	103 ± 11	95 ± 14	n. s.
Duration of ischemia (min)	57 ± 9	46 ± 12	< 0.05
Catecholamines (%) (*adrenaline, noradrenaline, dobutamine*)	33	48	< 0.05
IABP (%)	1.8	6.6	< 0.05
Controll. reperfusion (%)	5.4	19.8	< 0.05

Table 3 Postoperative parameters (I) in groups A (CR) and B (ICR)

	A	B	p
Mech. ventilation (h)	12.1 ± 3.4	20 ± 5.2	< 0.05
Duration of ICU (h)	72 ± 14	101 ± 14	< 0.05
Catecholamines (%)	38	54	< 0.05
IABP (%)	5.4	6.6	n. s.
CK (U/l) (first day)	148 ± 42	230 ± 65	< 0.05
CK-MB (% of CK) (first day)	10 ± 4	13 ± 5	n. s.
ECG-changes (ST, Q) (%)	10	8	n. s.
Arrhythmias (AF, VES) (%)	29	24	n. s.

Table 4 Postoperative parameters (II) in groups A (CR) and B (ICR)

	A	B	p
Periop. myoc. infarction (%)	2.2	6	< 0.05
Angina pect. postop. (%)	2.6	2.7	n. s.
LV-EF (+% compared to preop.)	10	8	n. s.
Region. dysdinesia (new) (%)	3.3	4	n. s.
Pulmonary edema (%)	21	29	< 0.05
Mortality in hospital (%)	3.2	6	< 0.05

Graft selection

Long-term event-free survival after CABG is

not only related to

the preoperative status of the patient

the progression of atherosclerotic disease in the native coronary arteries

but is also dependent on

the patency of the bypass conduits used

Vein grafts

- **Mild degree of stenosis**
- **Large myocardial flow demand in severely hypertrophied ventricle - Perioperative Hypoperfusion Syndrome**

Arterial Grafts

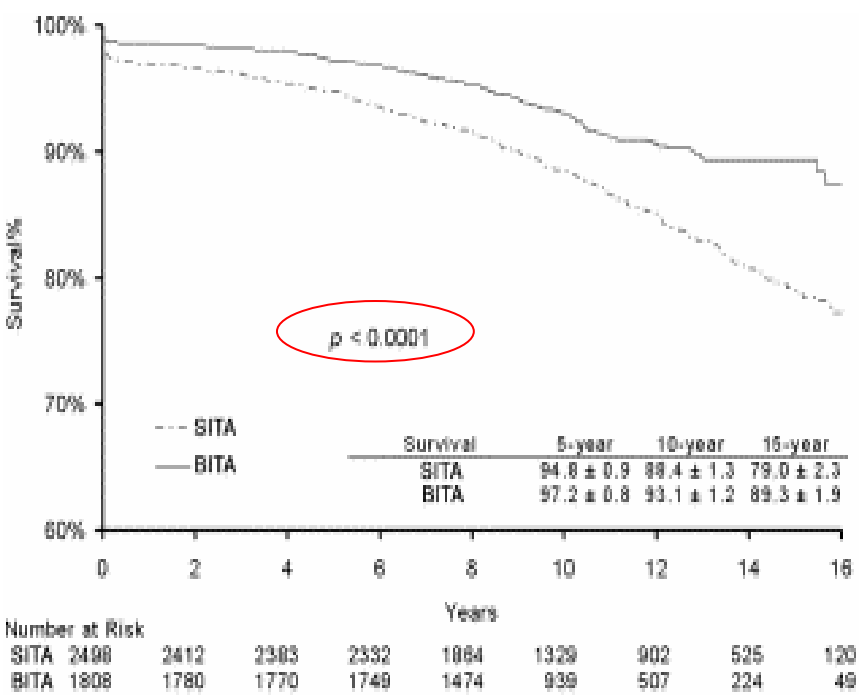
◆ ***Influence of the IMA graft on 10 year survival & other cardiac event –*** *Loop et al, N Engl J med 1986;314:1-6*

- ❖ **IMA to LAD with or without SV vs. only SV grafts**
- ❖ **10 year actuarial survival rate : 93.4% vs. 88%**
- ❖ **Risk of**

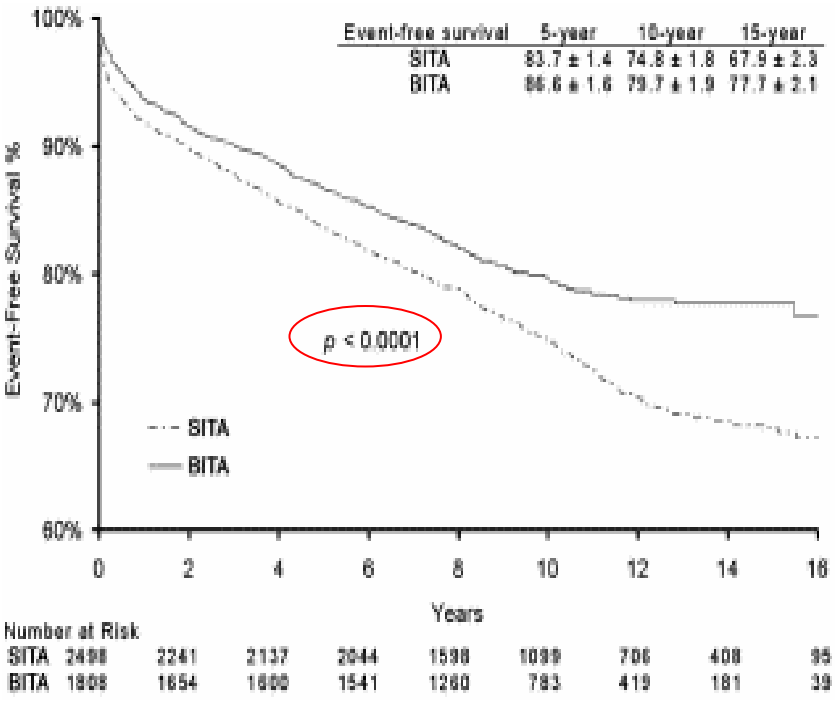
Death : 1.61 times
Late MI : 1.41 times
Hospitalization : 1.25 times
Cardiac Reoperation : 2 times

◆ *Single versus bilateral IMA grafts with concomitant saphenous vein grafts for multiessel coronary artery bypass grafting; Effects on mortality and event-free survival –* *Stevens, Cartier et al, JTCS 2004;127:1408-1415*

- **Single IMA + SV (n=2547) vs. BIMA + SV (n=1835)**
- **30 day mortality : 2.3% vs. 1.3% (p=0.007)**
- **10 year survival : 88% vs. 93%**
- **Hazard ratio : Death – 0.74, MI – 0.79, Reoperation – 0.41**



Kaplan-Meier survival



Event-free survival

OPCAB in LV Dysfunction

❖ ***Is low ejection fraction safe for off-pump coronary bypass operation*** *Arom KV, et al. Ann Thorac Surg 2000;70:1021-5*

- **EF ≤ 30%**
- **OPCAB : 45 patients vs. CABG : 132 patients**
- **Mean distal graft**

  OPCAB : 2.7 vs. CABG : 3.3 (p=0.001)
- **Op. mortality**

  OPCAB : 4.4 vs. CABG : 7.7 (p=ns)
- **Cardiopulmonary bypass was the only predictor for all postoperative complications (transfusion and CK-MB release)**

❖ *Surgical revascularization in patients with poor left ventricular function: On- or Off-pump?*

Shennib H. et al. Ann Thorac Surg 2002;74:S1344-7

- **EF ≤ 35%**

  OPCAB : 31 patients vs. CABG : 46 patients

- **Graft number**

  OPCAB : 2.8 vs. CABG : 3.9 (p<0.01)

  Fewer graft to OM and PDA

- **Mortality**

  OPCAB : 3.2% vs. CABG : 10.9% (p=0.39)

- **Less transfusion, less ventilatory support in OPCAB**
- **More atrial fibrillation in OPCAB**

  OPCAB : 29% vs. CABG : 10.9% (p<0.05)

❖ *Multi-vessel off-pump revascularization in patients with severe left ventricular dysfunction*

Goldstein et al. Eur J Cardiothorac Surg 2003:24:72-80

- **Retrospective study**
- **EF ≤ 30%**

  OPCAB : 100 patients vs. CABG : 110 patients
- **Mean grafts**

  OPCAB : 3.5 vs. CABG : 3.6 (p=ns)
- **Mortality**

  OPCAB : 3% vs. CABG : 10.9% (p=ns)

- **6 and 12 months survival**
  - **OPCAB : 90% and 85%**
  - **CABG : 82% and 75%** ***(p=0.592)***
- **The only statistically significant difference was postoperative renal failure (p=0.003)**
  - **OPCAB : 3% vs. CABG : 16%**
- **Factors attributed to low mortality**
  - **Achievement of multi-vessel revascularization**
  - **Liberal use of IABP**
    - **Preop. OPCAB : 16% vs. CABG : 24%**
    - **Intraop. OPCAB : 6% vs. CABG : 8%**
  - **Experienced cardiac anesthesiologist**

❖ ***Avoidance of cardiopulmonary bypass improves early survival in multi-vessel coronary artery bypass patients with poor ventricular function***

Dewey TM. Et al. The Heart Surgery Forum 2004;7(1):45-50

◆ **EF ≤ 30%**

◆ **OPCAB : 204 Patients vs. CABG : 713 patients**

◆ **Graft number**

OPCAB : 3.23 vs. CABG : 3.53 (p<0.001)

◆ **Mortality**

OPCAB : 2.9% vs. CABG : 6.3% (p=0.069)

◆ **Risk adjusted Mortality**

OPCAB : 1.5% vs. CABG : 4.1% (p<0.001)

◆OPCAB shows less morbidity

- ➢ Lower incidence of reoperation
- ➢ Lower blood product use
- ➢ Decreased postoperative ventilatory time
- ➢ Fewer days in ICU
- ➢ Lower incidence of IABP use

◆Logistic regression analysis

Cardiopulmonary bypass

and Previous bypass surgery

is an independent risk factors for death

❖ *Preoperative prediction of long-term survival after coronary artery bypass grafting in patients with low LVEF*

Derose et al. JTCS 2005;129:314-321

TABLE 2. Intraoperative characteristics, early mortality, length of stay and major complication after CABG in patients with low EF (≤25%, n = 544)

Intraoperative characteristics	
Two or more arterial grafts (No.)	259 (47.6%)
Number of distal anastomoses (mean ± SD)	3.4 ± 0.9
OPCAB (No.)	82 (15.1%)
Microscope use (No.)	234 (43.0%)
Early mortality and length of stay	
EuroSCORE standard (mean ± SD)	8.25 ± 2.82
30-d mortality (No.)	30 (5.5%)
In-hospital death (No.)	33 (6.1%)
Stay (d, mean ± SD)	13 ± 11.3
Major complications	
Intraoperative stroke (No.)	25 (4.6%)
Over 24 h stroke (No.)	4 (0.7%)
Postoperative myocardial infarction (No.)	5 (0.9%)
Deep sternal wound infection (No.)	9 (1.7%)
Bleeding/reoperation (No.)	14 (2.6%)
Sepsis/endocarditis (No.)	7 (1.3%)
Gastrointestinal bleeding, perforation, or infarction (No.)	12 (2.2%)
Renal failure/dialysis (No.)	11 (2.0%)
Respiratory failure (No.)	42 (7.7%)

TABLE 3. Potential predictors for long-term mortality in patients with low EF (≤25%) undergoing CABG (univariate Cox regression analysis)

Variable	HR	95% Confidence interval	*P* value
Age (continuous variable)	1.053	1.037–1.070	<.001
Body mass index (continuous variable)	1.047	1.016–1.079	.003
Emergency operation	1.83	1.30–2.58	.001
Urgent operation	0.71	0.55–0.97	.003
PVD	1.93	1.44–2.58	<.001
COPD	1.53	1.13–2.09	<.001
Current CHF	1.40	1.06–1.86	.019
Past CHF	1.50	1.11–2.04	.009
Calcified aorta	1.91	1.36–2.69	<.001
Immune deficiency	5.70	1.39–23.31	.016
OPCAB surgery	1.77	1.17–2.67	.007

5 year survival

OPCAB : 45% vs. CABG : 70%

OPCAB had higher Euroscore (9.3 vs. 8.0)

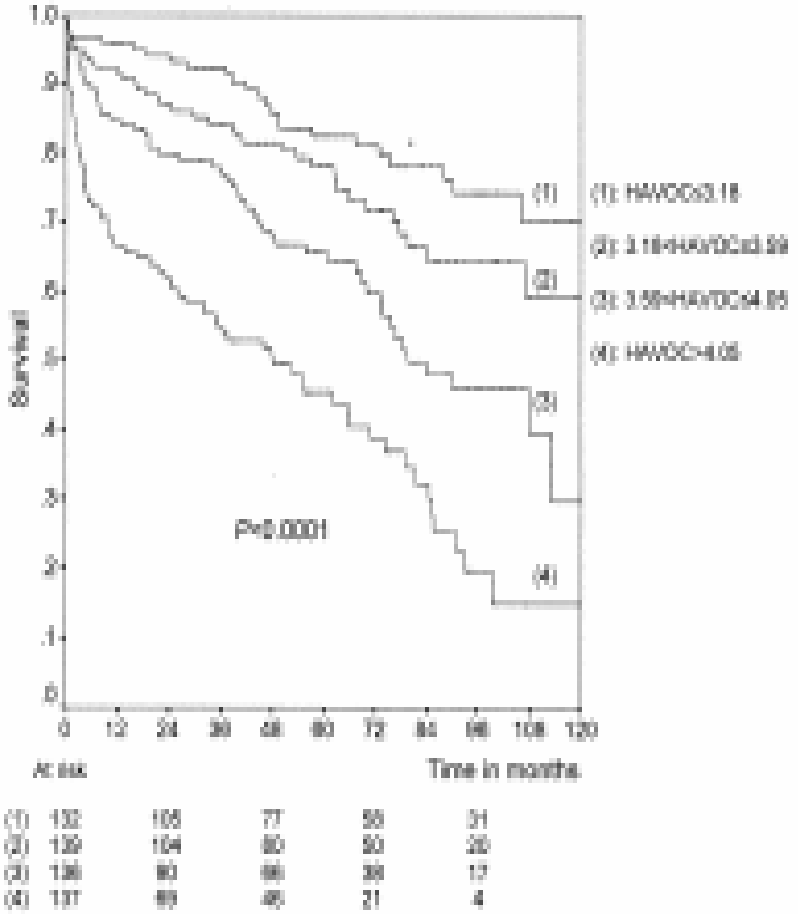


Figure 2. Kaplan-Meier curves of quartiles according to constructed HAVOC score of all patients with low EF (≤25%) undergoing CABG (n = 544).

❖ *Early and Mid-term impacts of cardiopulmonary bypass on coronary artery bypass grafting in patients with poor left ventricular dysfunction*

– A propensity Score Analysis -

Youn YN, Yoo KJ et al. Circ J 2007;71:1387-94

◆Isolated CABG : 1473 patients

◆EF ≤ 35% : 155 patients (10.5%)

Exclusion : 2 on-pump conversion from OPCAB surgery

Mean EF ; OPCAB : 28.8 ± 5.1 CABG : 28.1 ± 7.1

◆Off-pump group : 100

◆On-pump group : 53

Propensity score case matching

50 pts

50 pts

◆**Graft number**

OPCAB : 3.2 vs. CABG : 3.4 (p=ns)

◆**Total arterial bypass grafting**

OPCAB : 60% vs. CABG : 48% (p=ns)

◆**Complete revascularization**

OPCAB : 84% vs. CABG : 94% (p=ns)

◆**OPCAB group show**

more arterial graft

less Inotropic use, CK-MB release

Respiratory failure, ICU stay

◆**Expected mortality**

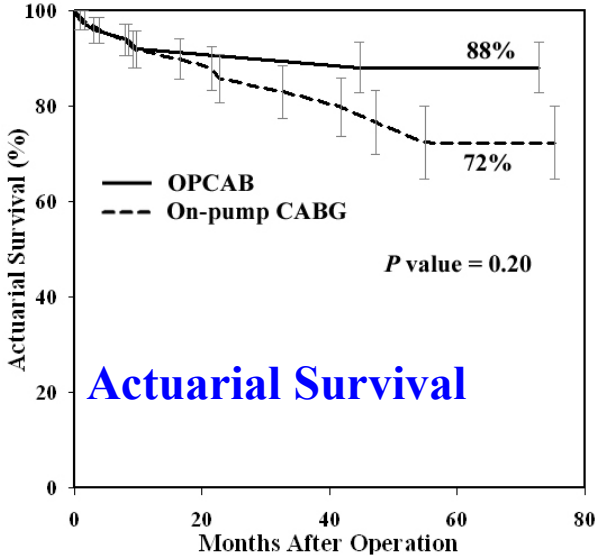
OPCAB : 11.2% vs. CABG : 10.1% (p=ns)

◆**Mortality**

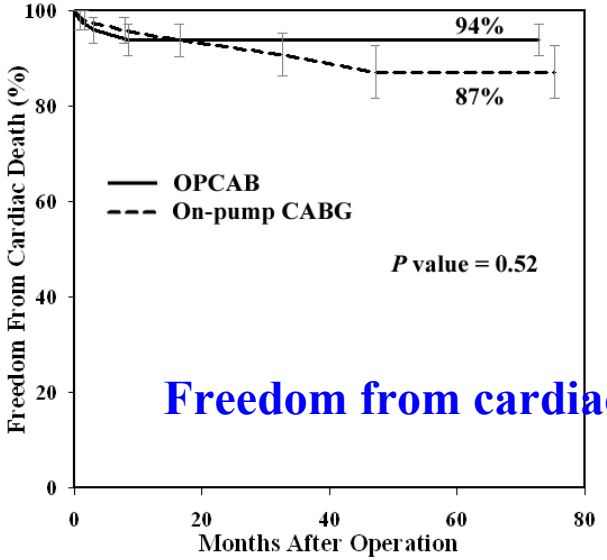
OPCAB : 4% vs. CABG : 2% (p=ns)

Mid-term outcomes

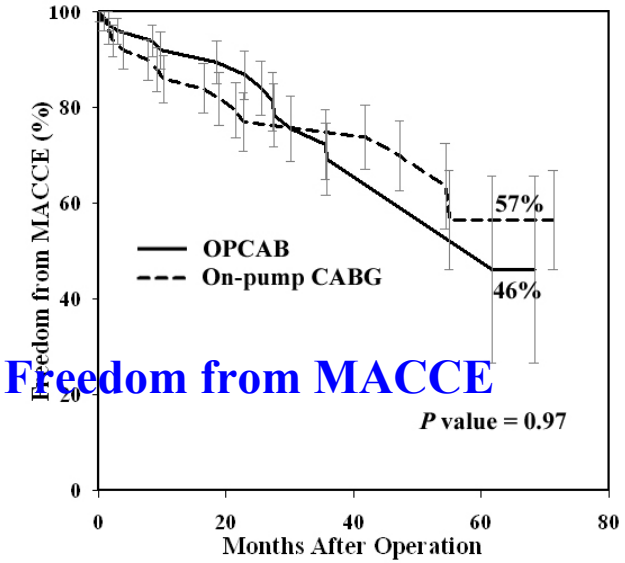
(mean f/u time: 35.5±17.3 (range, 4 to 72months))



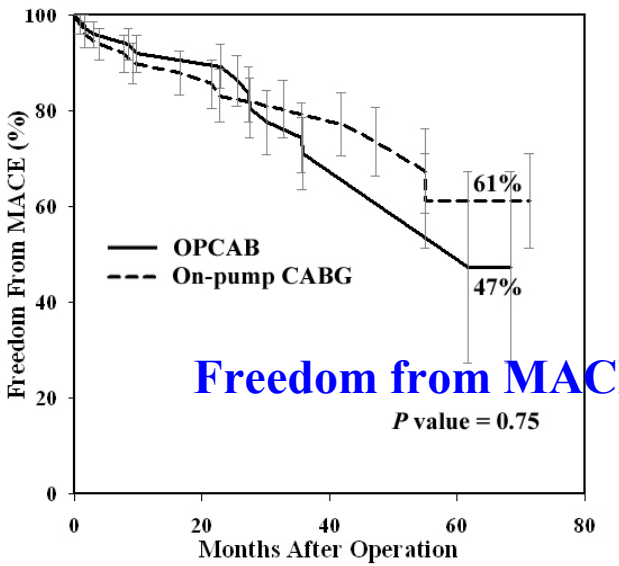
Actuarial Survival



Freedom from cardiac death

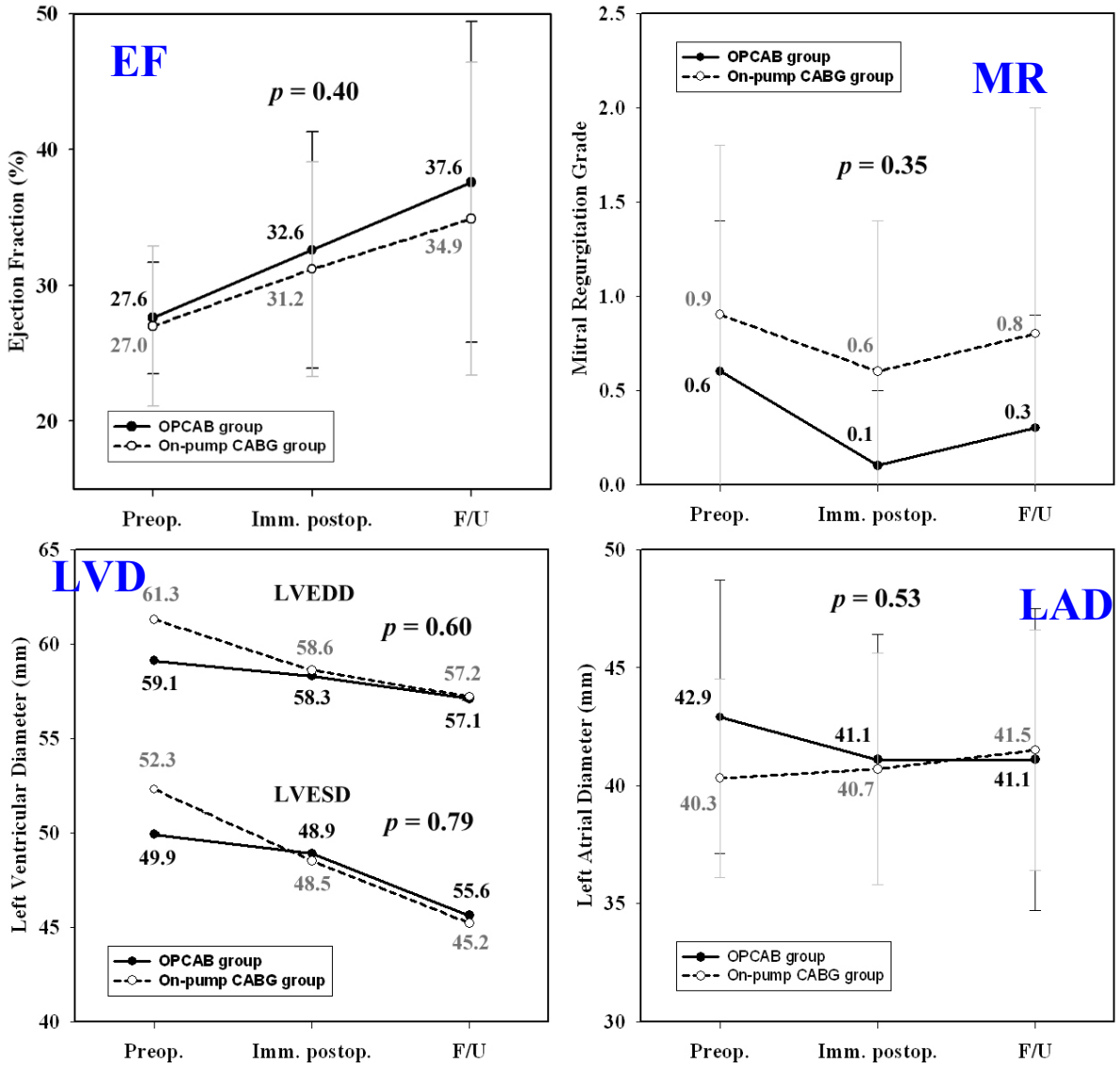


Freedom from MACCE



Freedom from MACE

Changes of Echocardiographic results



CABG versus PCI (Bare metal stent)

Early CABG versus medical therapy trials
Veterans Administration Trial of CABG for Stable Angina (VA Trial)
Veterans Administration Unstable Angina Cooperative Study (VA Study)
European Coronary Surgery Study (EURO)
Coronary Artery Surgery Study (CASS)
CABG versus PCI trials
Arterial Revascularization Therapies Study (ARTS)
Argentine Randomized Study (ERACI II)
Stent or Surgery (SoS) Trial
Emory Angioplasty versus Surgery Trial (EAST)
Bypass Angioplasty Revascularization Investigation (BARI)
Coronary Angioplasty versus Bypass Revascularization Investigation (CABRI)
First Randomized Intervention Treatment of Angina (RITA-1) Trial
First German Angioplasty Bypass Investigation (GABI-1)
Angina with Extremely Serious Operative Mortality Evaluation (AWESOME)

Conclusions of clinical trials

Caines AEB, et al. Cardiology 2004:101;21-8

Survival advantage with CABG compared to PCI or medical therapy alone in patients with low EFs
More freedom from angina symptoms and heart events with CABG
More complete revascularization with CABG
More need for revascularization with PCI
More periprocedural morbidity with CABG
PCI more cost-effective within the first year after intervention
PCI less cost-effective after 1 year of intervention because of need for repeat interventions

CABG versus PCI

-Drug eluting stent-

❖ ***Revascularization in severe left ventricular dysfunction: DES vs. CABG***

Gioia G et al. Catheter Cardiovasc Interv 2007;70:26-33

◆**Retrospective multicenter study**

◆**220 patients with LVEF <=35%**

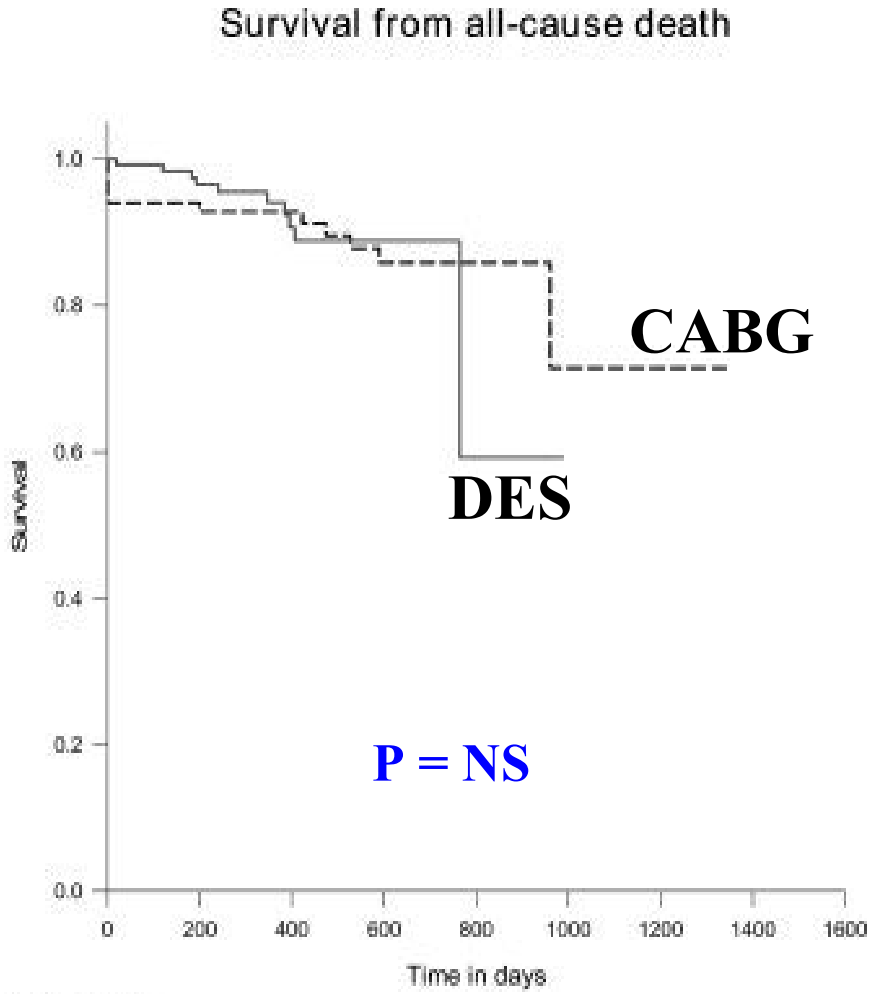
◆**DES : 128 patients CABG : 92 patients**

◆**Mean graft**

➢ **DES : 1.3 artery / pts, CABG : 3.0 ± 0.8 graft / pts**

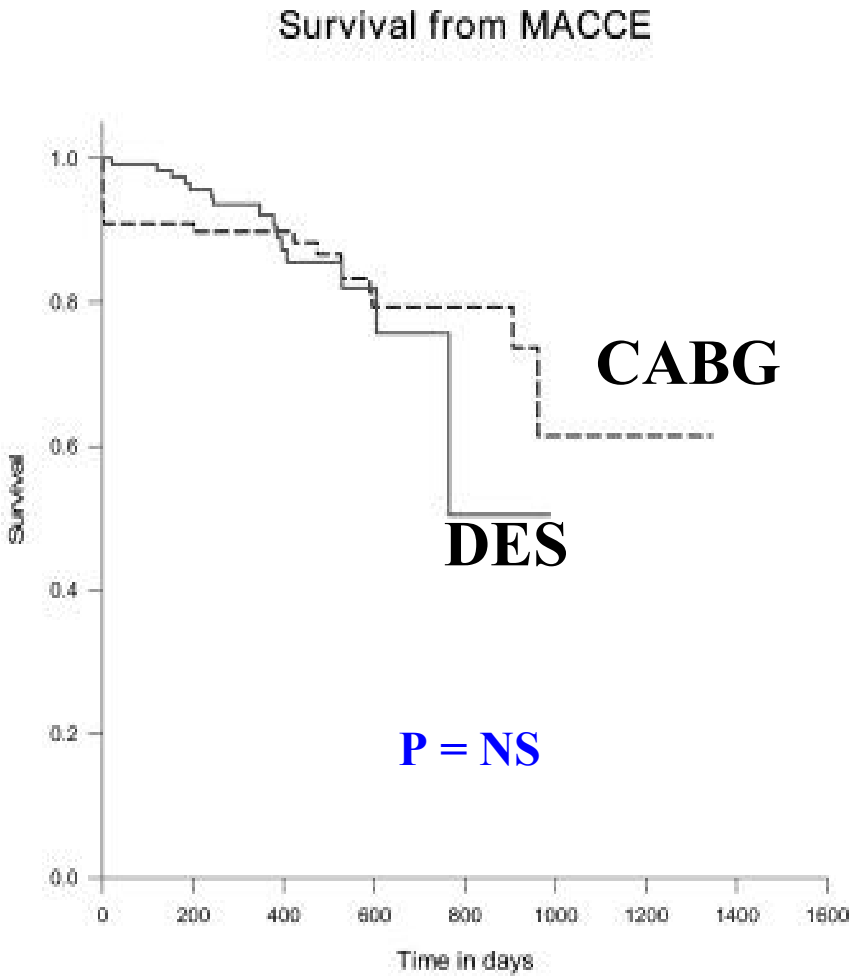
◆**Follow-Up : 2 years**

No difference in early and 2 year F-U results



Number at risk

CABG	92	78	65	46	21
DES	128	108	64	30	4



Number at risk

CABG	92	78	65	46	15
DES	128	108	60	20	3

Off-pump Coronary Artery Bypass Grafting in Patients with Low Ejection Fraction

-Yonsei experience -

Materials

- ◆Period : January 2001 ~May 2007
- ◆No. of Total CABG by single surgeon : 1412
- ◆No. of LV dysfunction (EF ≤ 35%)
  : 156 patients (11.0%)
- ◆On-Pump CABG : 34 patients
- ◆OPCAB : 122 patients

Demography (I)

- ◆Age : 62.1 ± 94
- ◆M : F = 94 : 28
- ◆Mean LV Ejection Fraction : 27.8 ± 5.8 %
- ◆Canadian class : 2.5 ± 0.9
- ◆NYHA class : 2.5 ± 0.9
- ◆Euroscore : 7.1 ± 3.6
- ◆Predicted mortality : 12.0 ± 13.9

Demography (II)

◆Risk factors

DM	78 (63.9%)
Hypertension	68 (55.7%)
Acute MI(<30days)	52 (42.6%)
PAOD	18 (14.8%)
CVA	15 (12.3%)
Renal failure	20 (16.4%)

◆Coronary disease

Left main disease or 3 VD 107 (87.7%)

◆Preop. inotropic usage 18 (14.8%)

◆Urgent or Emergency operation 17 (13.9%)

◆Preop. IABP 3 (2.5%)

Operative Data (I)

◆No. of Used Grafts	2.7 ± 0.6
LIMA	121 (99.2%)
RA	103 (84.4%)
RIMA	46 (37.7%)
SV	42 (34.4%)
GEA	5 (4.1%)

◆Y graft : 117 (95.1%)

◆Sequential graft : 34 (27.4%)

Operative Data (II)

◆**Target territories**

LAD territories : 174 anastomoses

LCx territories : 116 anastomoses

RCA territories : 90 anastomoses

◆**Total arterial bypass grafting 80 (65.6%)**

◆**Used arterial grafts (mean) 2.4 ± 0.8**

◆**Distal anastomoses (mean) 3.1 ± 0.8**

Postoperative Results

- ◆Postop. Inotrope use 24 (19.7%)
- ◆CK-MB (POD#1; mg/dL) 15.3 ± 34.1
- ◆Postop. bleeding for 24 hours (mL) 755.0 ± 331.2
- ◆Ventilation time (hrs) 22.4±31.1
- ◆ICU stay time (hrs) 62.3±36.0
- ◆Hospital stay (days) 14.2±8.4
- ◆Multi-slice CT evaluation :

  214 anastomoses (67 pts;54.5%)

  Patency rate : 98.6%(211/214)

Mortality and Morbidity

◆In-hosptial Mortality : 3 (2.5%)

- Cause of death : Acute MI and multiorgan failure (preop. CRF) (1), ventricular fibrillation (1), Hemothorax (1)

◆Morbidity

Atrial fibrillation	**16**	**(13.1%)**
Renal failure	**4**	**(3.3%)**
Perioperative MI	**3**	**(2.5%)**
Respiratory failure	**1**	**(0.8%)**
new IABP insertion	**1**	**(0.8%)**
Ventricular tachycardia	**1**	**(0.8%)**
UGI bleeding	**1**	**(0.8%)**
CVA	**1**	**(0.8%)**
Reoperation for bleeding	**0**	

Follow Up – 100%

- **Follow up period : 30.6 ± 22.4 mo. (3 ~ 77mo.)**
- **Late death : 9 patients**

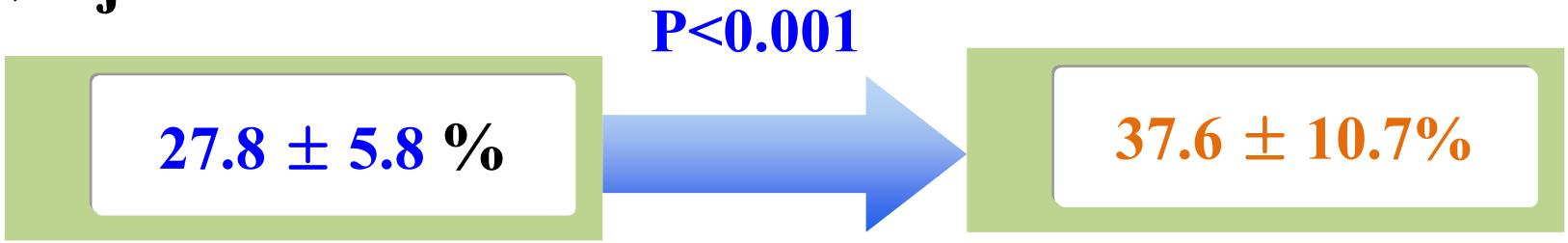
  Cardiac death : 6

  AMI(3), Heart failure(1), Sudden cardiac arrest (?) (2)

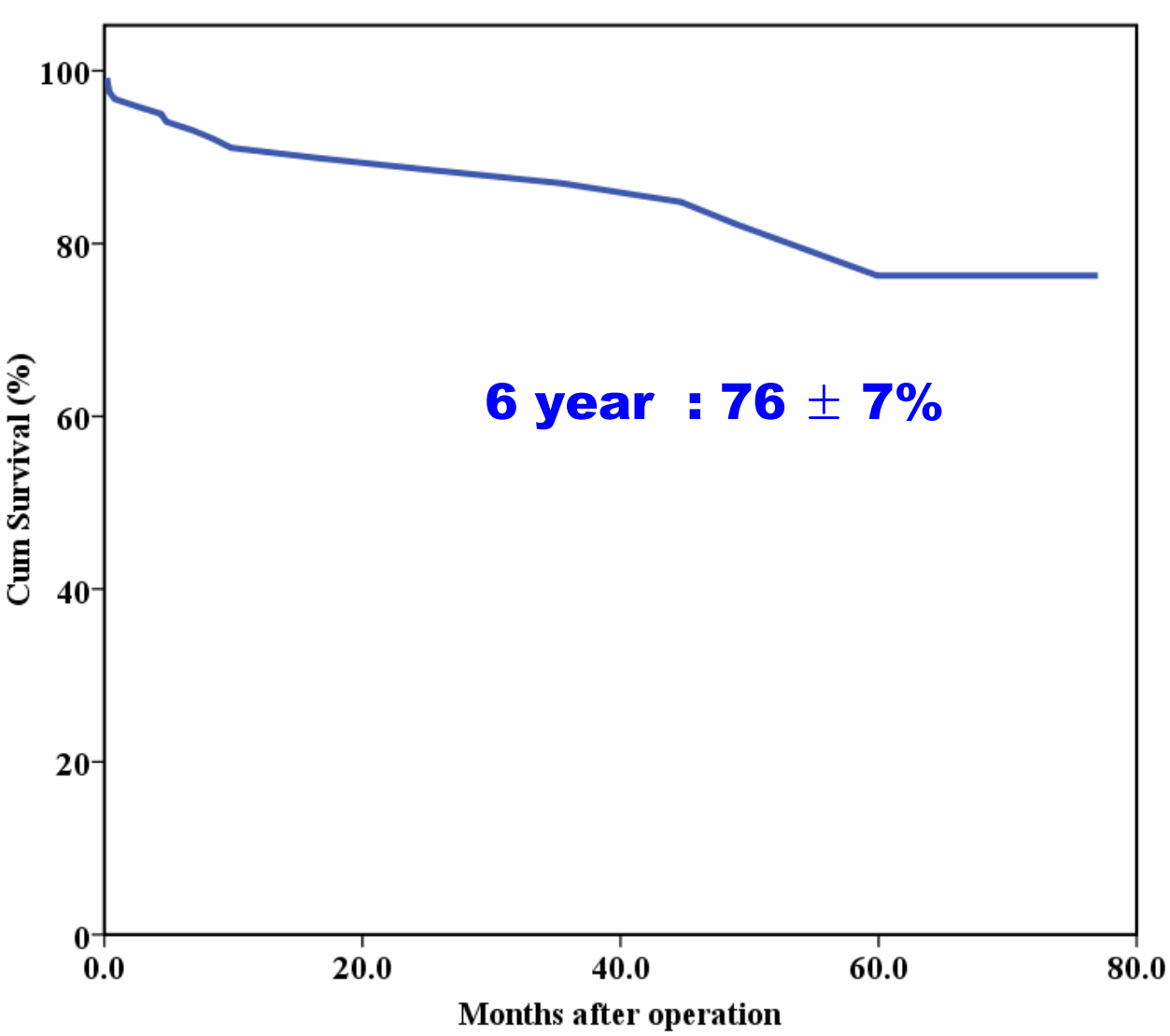
  Non-cardiac death : 6

  hepatoma (1), respiratory failure (1), cerebral infarction (1), ESRD (1), unknown (2)

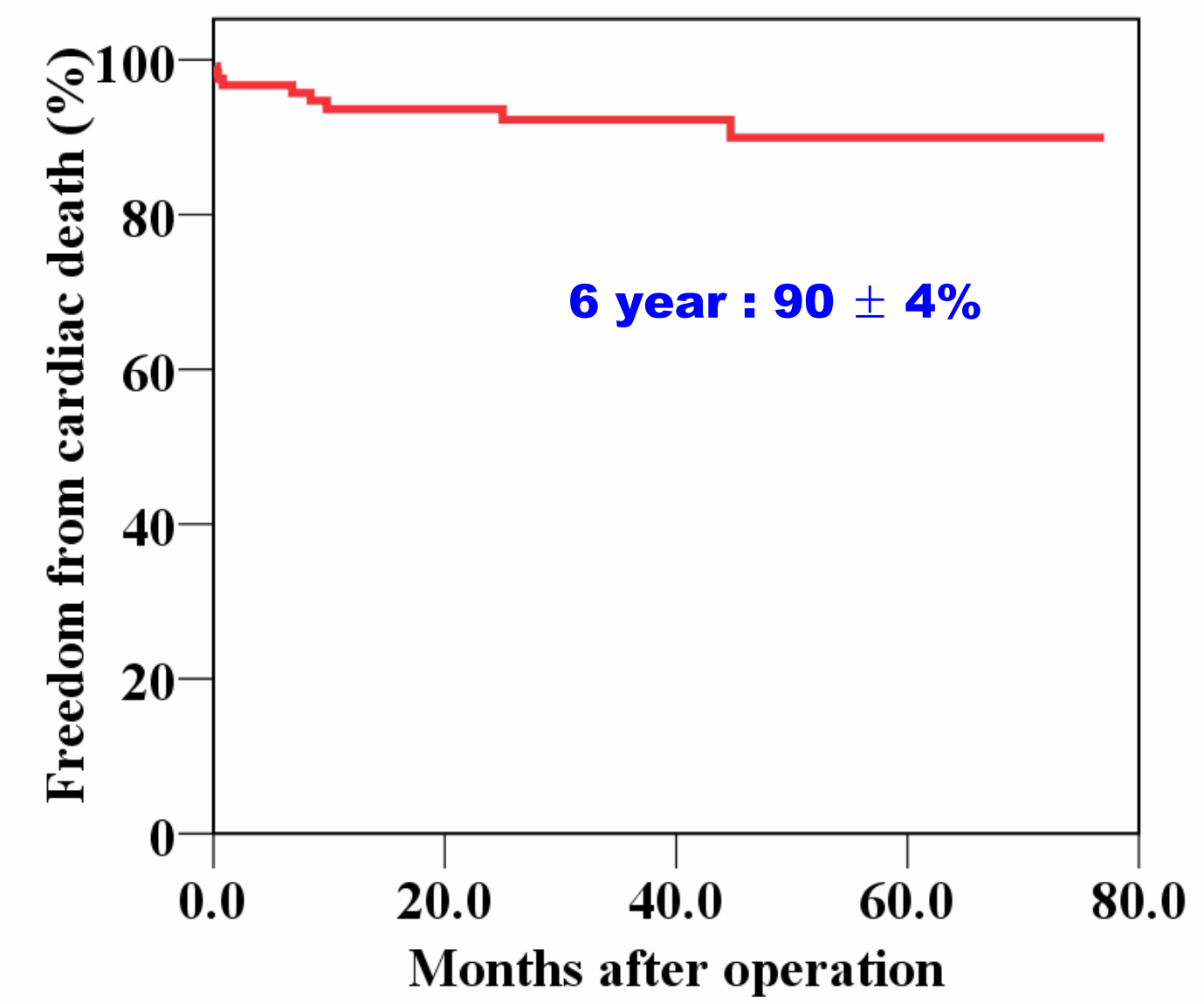
- **Ejection fraction**



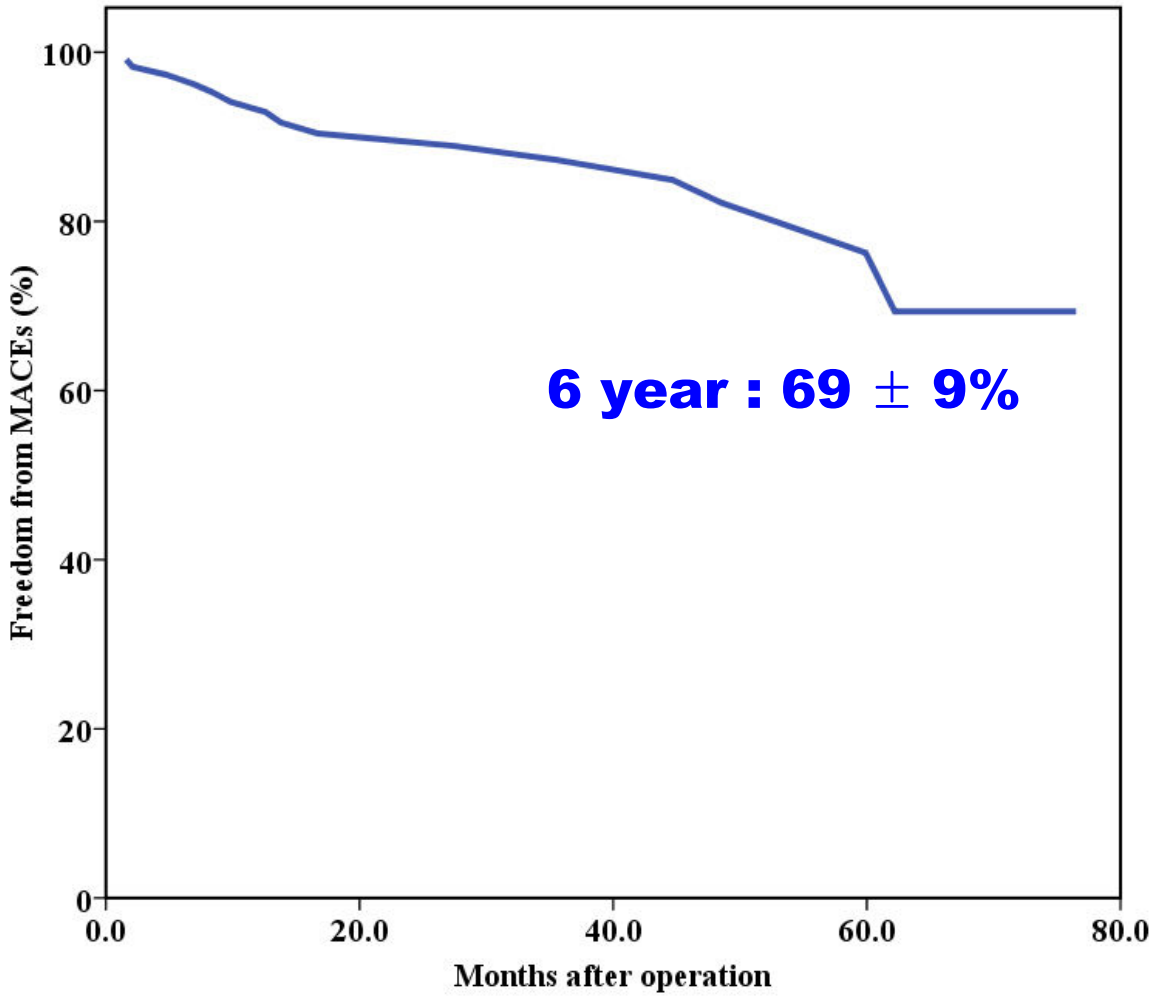
Actuarial survival



Freedom from cardiac death

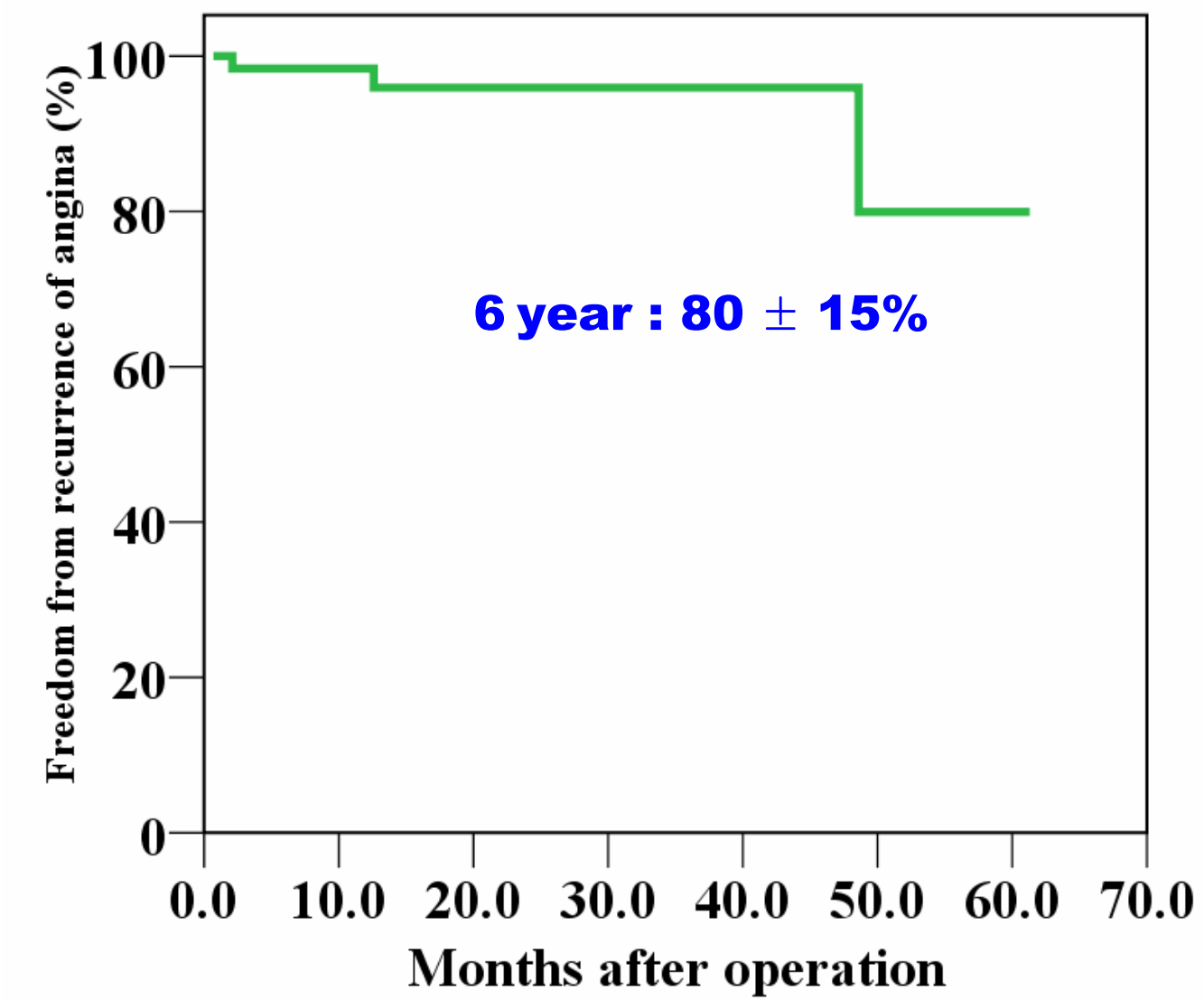


Freedom from MACE



- Major adverse cardiac events
  - All-cause late mortality (12), re-PTCA (2), non-fatal MI(1)

Freedom from recurrence of angina



Conclusions

- **OPCAB improves myocardial function and favors lower morbidities in patients with severe left ventricular dysfunction**

- **No difference in mid-term results between OPCAB and CABG**

- **In patients with low ejection fraction, *complete revascularization and total arterial OPCAB* may further improve long term results**