SCHOOL OF MEDICINE AND HEALTH SCIENCES
UNIVERSITY OF OTAGO, WELLINGTON

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Evaluation of a Coronary Artery Bypass Scoring Tool for Priority for Surgery

Supervised by: Professor Peter Larsen
Dr. Alexander Sasse

Sponsor: The Surgical Research Trust

LAY REPORT

Coronary artery bypass graft (CABG) surgery reinstates blood flow to heart muscle by bypassing blocked vessels. Patients needing CABG are at greater risk of heart attacks, heart failure, strokes and death-events referred to as MACE (Major Adverse Cardiac Events).

During 2006/2007 there was a dramatic increase in the length of the waiting list for Coronary Artery Bypass Graft (CABG) surgery at Wellington Regional Hospital. As a result of longer waiting times across New Zealand, the Clinical Prioritisation Score for CABG was developed. The patient's score is used to group them into one of four urgency categories, with a recommended maximum time for surgery. The intention is to aid clinicians in organising the waiting list so that higher risk patients have surgery sooner. CPS is used in all major cardiac surgical centres in New Zealand already, and is due to be formally implemented.

This study was undertaken to see if CPS is achieving its purpose. To do this we looked at patient's medical records and applied the scoring system retrospectively. We found that surgery within the CPS time frame did not decrease frequency of MACE. Additionally we found that the estimated probability of survival at the CPS recommended maximum time differed between urgency groups, suggesting that patients allocated to different groups would be being allocated different levels of risk of having an adverse event. The results of this study suggest that CPS is not an entirely effective system and may not be a fair way to list patients. The sample size was small, so a larger study which looks at other outcomes as well would be useful.

SCIENTIFIC REPORT

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Te Whare Wānanga o Otāgo

NEW ZEALAND

Validation of the New Zealand Clinical Priority Scoring System for Coronary Artery Bypass Graft Surgery

Gloria Ashton

Supervisors:
Associate Professor Peter Larsen,
and Dr Alexander Sasse

SPONSORED BY THE SURGICAL RESEARCH TRUST

Location: Wellington Regional Hospital
Date: 7/01/2012

▪Introduction

In 2006 to 2007 there was a dramatic increase in the number of patients on the waiting list for cardiac surgery at Wellington Regional Hospital (WRH) (1). The Cardiac Surgical Centre at WRH services a population of 900,000 spanning across 7 District Health Boards (DHB) (1). There were multiple factors contributing to the increased number of patients awaiting cardiac surgery. These factors include a 40% increase in referrals to Capital & Coast DHB for elective cardiac surgery between 2004 and 2006, an increase in acute cases requiring urgent surgery, and inadequate capacity of the healthcare system to cope with increased demand (1). In July 2007 there were 120 patients who had been waiting over 6 months for cardiac surgery. In 2008, the rates of cardiac surgery in New Zealand were still lower than in comparable developed countries (1). With longer waiting times it became more important to rationalise the waiting lists in such a way that patients with highest need would have surgery sooner.

Since 1998, New Zealand has used a scoring system to assess patients referred for coronary artery bypass graft (CABG) surgery, the Clinical Priority Assessment Criteria (CPAC). CPAC was used to limit access onto the publicly funded CABG waiting list to patients who scored over a threshold. It was developed by a panel of clinicians using a modified Delphi consensus method (2). This system was not used to prioritise patients according to the urgency of their surgery once on the list. CPAC was criticised for comprising criteria that poorly reflected the risk and benefit to the patients, and for using essentially arbitrary points values.

More recently, the Clinical Priority Score (CPS) for CABG has been formed in response to lengthening waiting-lists across New Zealand. The development of a new scoring system began in 2004, as collaboration between the Ministry of Health/New Zealand Cardiac Surgical Network and the New Zealand region of the Cardiac Society of Australia and NZ (CSANZ). A group of cardiologists and cardiac surgeons from across New Zealand were involved. The development process involved scoring of case vignettes, agreement on criteria and weighting, and feedback from clinicians. CPS aims to predict the urgency of surgery, aiding clinicians in creating a risk-stratified waiting-list in which risk is minimised and benefit maximised. There are 4 CPS urgency groups with recommended time frames, they are as follows; I/H (In-hospital: 72 hours or 3 days), Urgent (10 days), Semi-urgent (30 days), Routine (120 days). The system has been formally accepted by CSANZ and is already in use in the 5 major cardiac surgical centres in New Zealand. It is due to be formally implemented in 2012 to 2013 (3).

This is the first study to assess the capability of the CPS system to effectively reduce risk on the waiting list for CABG surgery. A similar study focussing on valve surgery has already taken place at WRH (yet to be published), the results of which indicated that CPS was not effective at reducing the frequency of MACE during waiting time (4). Our hypothesis, based on this finding, is that the CABG CPS system also does not adequately reduce risk on the waiting list.

▪Aim & Hypothesis

To evaluate the efficacy of the CPS system for reducing risk of MACE while on the waiting list, by retrospectively applying the scoring system and observing frequency of MACE. We hypothesise that the CPS system does not significantly reduce risk, and does not distribute risk fairly across urgency groups.

▪Design

This is a retrospective, single centre, observational study. A hospital database was searched for all patients waitlisted for CABG surgery at WRH from January 2007 to February 2009.

Exclusion criteria were:

- Valve surgery as the primary indication for cardiac surgery
- Patients wrongly listed for CABG surgery (e.g. aortic dissection)
- Patients placed under 'active review' rather on the waiting list
- Emergency cardiac surgery

The resulting study population consisted of 315 patients.

Cardiothoracic files of all patients were requested. Information from the files was collated with any available electronic records, and entered into a spreadsheet by two cardiology registrars and a medical research assistant.

The date of inclusion into the study corresponds with the date the patient was accepted onto the CABG surgery waiting list. These dates were taken from either letters of acceptance sent to patients, or 'received' dates on accepted referral forms.

End-points recorded were the date of surgery, death on the waiting list, or removal from the waiting list. Patients who opted for private surgery and

were therefore removed from the waiting list had their end-point recorded as the date of private surgery.

An online scoring tool was used to calculate the CPS of each patient by entering the clinical characteristics of the patient at the time of inclusion into the study. The CPS tool uses the following parameters: coronary anatomy, severity of stable angina, territory at risk, left ventricular ejection fraction, acute coronary syndrome during last 2 weeks, troponin rise, LVF due to ischaemia, predicted benefit to quality of life after surgery, expected duration of benefit of surgery, risk of cardiac surgery **(See appendix; Figure 1)**. The risk of cardiac surgery is determined from the patient's EuroSCORE, which was calculated on our spreadsheet using information from patient records. The patient's CPS score, urgency group, and the associated recommended time frame were all recorded.

Many patients presented with a myocardial infarction (MI) and were referred for surgery during their admission. In these circumstances, patients documented as being free of post-infarction angina while on the ward were scored as CCS 0 angina. If absence or presence of chest pain was not documented they were recorded as having CCS 4 angina.

The primary outcome observed was a major adverse cardiac event (MACE) occurring while the patient was on the waiting list. Adverse events recorded were limited to death, cardiovascular death, new MI, stroke, emergency cardiac surgery (within 48 hours), new heart failure (pulmonary oedema or requiring admission and vasodilation/increase in diuretic dose) and new arrhythmia (requiring CPR or admission and initiation/change of pharmacotherapy).

Data collection was performed as part of an audit of the CABG services at WRH. Other data collected included presence of a range of co-morbidities and prescribed medications at the time of referral. This allows comparison of the types of patients stratified into each group, and an overview of patient characteristics in the overall study population.

▪Rationale

There have been no studies to date validating the CABG CPS system. The period of time observed was chosen due to the increased length of time on the waiting list for cardiac surgery over 2006 to 2009 at WRH. This allowed comparison of frequencies of MACE occurring inside the CPS recommended time frames, with those outside of the time frames. Applying the score retrospectively rather than using parameters entered in old CPAC score

sheets eliminated the distortion of data which may have occurred with clinicians inflating their patient's scores. The CPS system is already widely in use and is soon to be formally instated, a retrospective analysis allowed for more timely evaluation of CPS in a larger cohort of patients than a prospective study.

▪Results

Study Population

The study population after application of inclusion/exclusion criteria, was 315 patients. 288 patients were included in results analysis, the remaining 27 were excluded due to insufficient information available in hospital and electronic records.

Patients characteristics of the overall study population, and stratified according to urgency category, are reported in **Table 1 (See appendix)**. The study population was predominantly male (78.1%), with a mean age of 63.6±9.6 years. 267 patients went on to have surgery. 21 were removed from the waiting list, mostly due to patient choice. The majority of patients had isolated CABG surgery, with only 3.2% (9/288) of the study population having simultaneous valve replacement, of either the aortic or mitral valve. As previously mention in methodology, all primary referrals for valve surgery were excluded from the study. Of the patients who went on to have surgery, the average number of grafts performed was 3. This was the same across all urgency groups. Canadian Cardiovascular Society (CCS) angina class 3 and 4 were most common, together accounting for 76.4% of angina symptoms.

Patient Characteristics Compared between Urgency Groups

Table 1 (See appendix) shows patient characteristics stratified according to CPS urgency group. The majority of patients were categorised into the Routine and Semi-urgent groups, a total of 175/288. Females, making up 21.9% of the study population, were overrepresented in the I/H group (29.8%). The average age was similar between urgency groups.

Prevalence of history of ventricular tachycardia (ns- or s-VT) and prevalence of previous MI increased with increasing urgency status. Other risk factors did not show clear trends across urgency groups. Diabetes Mellitus and current smoking status, were more prevalent in the I/H group. Prevalence of mild and severe left ventricular impairment (EF 30-50% and EF<30%)

showed increasing trends across increasing urgency groups). In the 3 highest urgency groups the most common angina class was CCS 4, with frequency increasing with urgency status. Prescription of a diuretic increased with increasing urgency status. Prevalence of other prescription medications was similar across urgency groups.

MACE during Waiting Time

Average waiting time for patients who went on to have surgery was 81.9±90 days. Across all CPS urgency groups, average waiting time was outside of the corresponding recommended maximum time frame for surgery. This discrepancy was most pronounced in the Urgent group, with an average waiting time of 71 days, well outside of the recommended time frame of 10 days. The minority of patients were operated on within the recommended time frame (39.0%). The proportion operated on within the recommended time frame was less than 50% across all groups, and higher urgency groups were less likely to achieve surgery within the recommended time frame **(See appendix; Table 1)**.

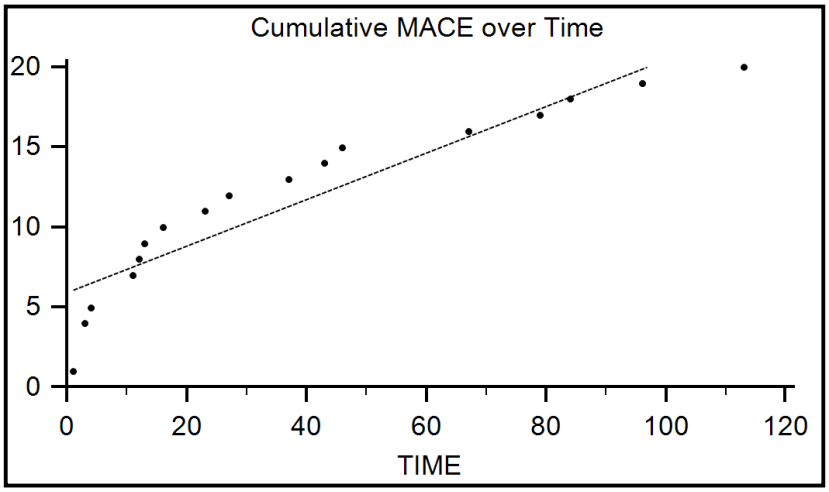
20 patients suffered MACE while on the waiting list, a frequency of 6.9%. 6 of these patients died, a mortality frequency of 2.1%. The frequency of MACE during waiting time increased with increasing urgency status, as shown in
Table 3. 10 MACE occurred within the recommended time frame for surgery, while the remaining 10 occurred outside of the time frame. The most common MACE event was new myocardial infarction. Details of patients suffering MACE during waiting time are shown in **Table 2.**

Table 2 Information on Patients Suffering MACE

Patient	Gender	Age	CPS Urgency Score	RTF (days)	Days until MACE	Days on w/l	CABG within RTF (Y/N)	Type of MACE
1	M	59.72	64	3	23	23	N	CV death
2	F	44.16	59	3	16	16	N	New MI, CV death
3	F	71.41	50	3	37	55	N	New MI
4	M	58.71	53	3	3	13	N	Stroke
5	M	64.99	57	3	46	46	N	New MI
6	F	73.66	75	3	1	1	Y	CV death
7	M	68.15	49	10	67	75	N	New MI
8	M	61.86	45	10	4	17	N	Relevant arrythmia
9	M	63.70	42	10	113	258	N	New MI
10	F	77.97	49	10	2	27	N	Stroke
11	M	70.10	49	10	11	11	N	Death-cause NR
12	M	55.18	40	10	84	84	N	Stroke, Death
13	F	76.32	35	30	3	29	Y	New MI
14	F	71.00	25	30	11	14	Y	New MI, Emergency cardiac surgery
15	M	76.46	38	30	12	21	Y	New MI
16	M	73.30	25	30	96	102	N	New MI
17	F	69.97	32	30	3	14	Y	New MI, New heart failure
18	M	50.78	26	30	79	101	N	New MI, Emergency cardiac surgery
19	M	73.88	38	30	13	13	Y	New heart failure, Death-cause NR
20	M	63.03	14	120	43	63	Y	New MI

Table 3 **MACE during Waiting Time**

	Routine		Semi-urgent		Urgent		I/H		Total	
	120 days		30 days		10 days		3 days			
	84		91		56		57		288	
Patients	1	1.2%	7	7.7%	6	10.7%	6	10.5%	20	6.9%
No. of patients with MACE	1	1.2%	5	5.5%	2	3.6%	2	3.5%	10	3.5%
Within CPS time frame	0	0.0%	2	2.2%	4	7.1%	4	7.0%	10	3.5%
Outside CPS time frame										
	0		1		2		0		3	
Death	0		0		0		3		3	
CV Death	1		6		2		3		12	
MI	0		2		0		0		2	
New HF	0		0		1		0		1	
Relevant arrythmia	0		2		0		0		2	
Emergency cardiac surgery	0		0		2		1		3	
Stroke	0		0		0		0		0	
Removal from waiting list										



The frequency of MACE in patients who underwent surgery within the recommended time frame was 6.4% (7/109), and 7.3% in those who did not. (13/179) **(See Table 4).** There were 4 patients who had MACE within the recommended time frame and went on to have surgery outside of the recommended time frame. Analysis was repeated, this time comparing frequency of MACE between the group of patients who had either surgery or MACE within their recommended time frame (**See Table 5)** The results show frequencies of 8.9% (10/112) and 5.7% (10/176) respectively. A Chi-squared test was performed using Excel, generating a P-value of 0.29. This indicates that the different frequency of MACE in these two groups was not on a statistically significant level. Being removed from the waiting list was included as 'having had surgery'.

Table 5

Operated on within RTF	MACE	Total patients	% MACE
Yes	7	109	6.42%
No	13	179	7.26%
Total	20	288	6.94%

Table 4

Operated or MACE within RTF	MACE	Total patients	MACE %
Yes	10	112	8.93%
No	10	176	5.68%
Total	20	288	6.94%

Kaplan-Meier survival curves were generated using MedCalc. **Figure 3**. shows different shaped survival curves for each urgency group (P-value: 0.001). The Urgent and Routine groups had MACE event probabilities of 2% or lower at their respective recommended time frames of 10 and 120 days. The I/H group had a probability of 3.6% at 3 days. The Semi-urgent group had a probability of 6.8% at 30 days **(See Figure 2)**.

Figure 2

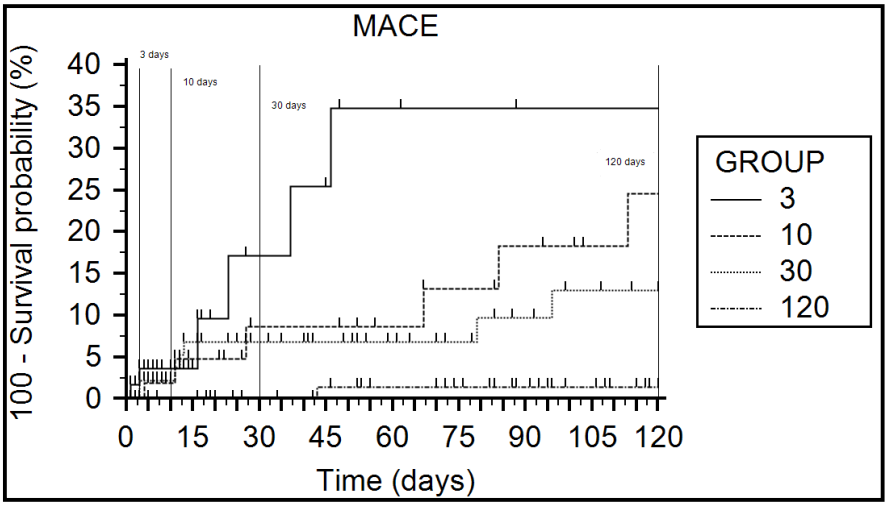
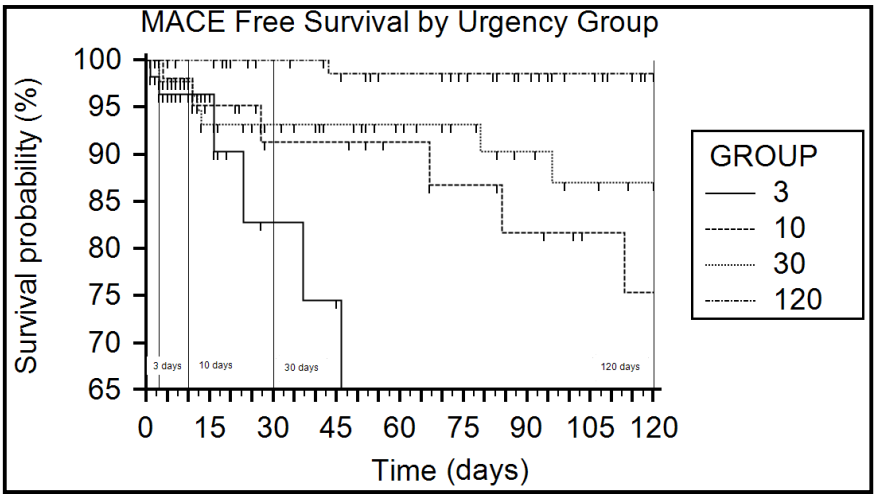


Figure 3



For the censored cases the time observed was either until surgery or removal from the waiting list. Results of log-rank testing are shown in **Appendix; Figure 4.**

Discussion

In this study we found that 6.9% of patients suffered MACE while on the waiting list for CABG surgery, with an overall mortality frequency of 2.1%. Of the study population, the majority (61.0%) had surgery outside of the recommended time frame. This finding reflects the time period covered by the study, as WRH struggled to cope with the increase in number of patient referred for cardiac surgery.

Of the 20 patients who suffered MACE, 10 instances would have been prevented had surgery been performed within the CPS timeframe. This reflects that a larger proportion of the patients had surgery outside of the recommended time frame. The rate of MACE in patients who had surgery within the recommended time frame was not found to be statistically significantly lower than in those who did not. Therefore the CPS recommended time frames were found to not be useful in decreasing MACE.

We found that the MACE free survival curves for each urgency group were statistically significantly different **(See appendix; Figure 4)**. It appears that the CPS urgency grouping does not continually stratify patients according to their probability of suffering MACE over time. These curves show that the ability of CPS recommended time frames to promote MACE free survival differed between the urgency groups. This suggests that placement of patients on the waiting list in accordance with their CPS recommended time frame would be allocating patients to different levels of risk of having a MACE while they are awaiting surgery.

Despite the length of time observed, the single centre nature of this study means a limited sample size of 332 patients, with only 20 instances of MACE. MACE rates in populations waiting for cardiac surgery tend to be low, therefore a larger sample size is required to investigate the utility of the CPS tool to reduce adverse events on the waiting list. This retrospective study relied heavily on accurate medical records. This may have been a limitation on the number of MACE identified, as the study assumed all major adverse events were adequately documented.

The accuracy of scoring patients relied upon the available information in patient records. In circumstances where a patient was referred for CABG during admission for an MI, and chest pain on the ward was not

documented, the assumption was made that they had CCS 4 angina. This assumption may mean some patients were incorrectly placed in higher urgency CPS groups and subsequently the ability of CPS to reduce risk on the waiting list would be over estimated.

Patients removed from the waiting list by choice were included in analysis of MACE frequency as 'having had surgery' at their removal date. These patients were often removed early on and may have been less likely to experience MACE. This may contribute to underestimation of MACE in the 'within time frame' group.

A study conducted in the Netherlands, a country with shorter waiting lists than New Zealand, found a mortality rate of 0.6% (5).This illustrates the potential to reduce mortality rates with more timely CABG surgery. Much progress has been made in reducing the length of waiting lists in New Zealand. A National Cardiac Surgery update released in June 2011 showed patients are now waiting an average of just 6 weeks for cardiac operations compared with 6 months in 2004/2005 (3). However, the study of mortality during waiting time in the Netherlands found a high rate of mortality occurred within 6 weeks of waiting time (5). Our study also shows over half of MACE events occurring within 6 weeks. Urgency scoring continues to be necessary. The public healthcare system is not able to supply CABG immediately, for this reason, and due to the nature of MACE, there will always be a risk involved in waiting. An effective scoring system should reduce the frequency of MACE to as close as possible to this residual risk, and ensure a fair system where all patients on the waiting list experience the same level of risk. It is important to be able to identify the level of the risk on the waiting list and discuss this transparently with patients.

Long waiting lists for CABG surgery are frequent in countries that provide universal access to healthcare. The Ontario score uses similar criteria to the CPS to stratify patients according to urgency and provide a recommended maximum time until surgery. A study of the Ontario score in Brazil collected data on a composite end-point of sudden or cardiac death, MI, unstable angina or hospital admission (6). The study found that a higher frequency of the composite end-point occurred in patients having surgery within the recommended times, and only one urgency group adequately predicted the need for urgent surgery (6). However, other studies have shown the Ontario score system to decrease mortality rates (6). This reflects the difficulty of producing, and the universal need for an accurate urgency scoring system. It also suggests that a system may not retain its predictive value between different populations.

EuroSCORE is a well-recognised and widely used measure for risk of intervention in cardiac surgery. EuroSCORE has been validated with good results in North America (7), and Brazil (8) However, a study completed in Australia found that EuroSCORE was not useful in predicting risk of cardiac surgery in the Australian population (9). CPS has not been evaluated in its ability to predict perioperative and post-operative outcomes. The ability of CPS recommended time frames to reduce these outcomes is yet to be assessed. This information is necessary to allow full assessment of the usefulness of CPS for the CABG waiting list.

Many patients in our study were readmitted with worsening angina symptoms and upgraded to higher urgency groups. Further studies into these outcomes would be useful to determine the efficacy of the CPS system in reducing illness in patients awaiting surgery and the subsequent burden on the healthcare system. A study in New Zealand found that nearly 20% of patients were readmitted with unstable angina or myocardial infarction and then preceded to surgery as an inpatient (10).

The CPS score is only partially effective at predicting urgency of surgery. The recommended time frames for surgery neither reduced risk of MACE, nor fairly distributed risk. Further studies with a larger cohort of patients are necessary, and a prospective study would increase the probability of detecting all MACE in the population. It may be necessary to revise the scoring system to provide the best possible outcomes for patients and to reduce stress on the healthcare system.

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▪Appendix

CPAC: Assessment Tool (CABG)

Figure 1

Table 1 Patient Characteristics

	Routine		Semi-urgent		Urgent		I/H			
	120 days		30 days		10 days		3 days		Total patients	
Patients	84		91		56		57		288	
Female	11	13.1%	22	24.2%	13	23.2%	17	29.8%	63	21.9%
Male	73	86.9%	69	75.8%	43	76.8%	40	70.2%	225	78.1%
Average age	64.70		63.20		62.91		63.60		63.64	
STD deviation	8.13		9.92		10.72		9.81		9.60	
Average waiting time	126.51		81.70		71.32		27.33		81.12	
STD deviation	80.01		83.61		104.80		60.43		90.48	
Removed from list/died	3		7		3		8		21	
Had surgery	81		84		53		49		267	
Operated within RTF	40	49.4%	38	45.2%	21	39.6%	5	10.2%	104	39.0%
Operated outside RTF	41	50.6%	46	54.8%	32	60.4%	44	89.8%	163	61.0%
Valve replacement										
Total No.	4	4.8%	3	3.3%	0	0.0%	2	3.5%	9	3.1%
AV	1	1.2%	2	2.2%	0	0.0%	1	1.8%	4	1.4%
MV	3	3.6%	1	1.1%	0	0.0%	1	1.8%	5	1.7%
Risk factors										
HTN	58	69.0%	53	58.9%	29	51.8%	41	71.9%	181	63.1%
DM	24	28.6%	28	31.1%	10	17.9%	22	38.6%	84	29.3%
Treated HLD	62	73.8%	71	78.9%	44	78.6%	42	73.7%	219	76.3%
Smoker	11	13.1%	23	25.6%	11	19.6%	15	26.3%	60	20.9%
AF	5	6.0%	8	8.9%	5	8.9%	4	7.0%	22	7.7%
VT	2	2.4%	2	2.2%	3	5.4%	4	7.0%	11	3.8%
Prev. MI	19	22.6%	28	31.1%	18	32.1%	19	33.3%	84	29.0%
EF 30-50%	22	26.2%	24	26.4%	25	44.6%	27	47.4%	98	34.0%
EF <30%	0	0.0%	4	4.4%	1	1.8%	8	14.0%	13	4.5%
CCS Angina										
0	3	3.6%	13	14.3%	4	7.1%	2	3.5%	22	7.6%
1	2	2.4%	4	4.4%	5	8.9%	0	0.0%	11	3.8%
2	18	21.4%	14	15.4%	0	0.0%	3	5.3%	35	12.2%
3	53	63.1%	24	26.4%	11	19.6%	7	12.3%	95	33.0%
4	8	9.5%	36	39.6%	36	64.3%	45	78.9%	125	43.4%
Medications										
B-blocker	70	83.3%	76	85.4%	45	80.4%	45	78.9%	236	82.5%
CCB	21	25.0%	28	31.5%	12	21.4%	8	14.0%	69	24.1%
ACE-I/ARB	42	50.0%	41	46.1%	24	42.9%	24	42.1%	131	45.8%
Statin	70	83.3%	81	91.0%	54	96.4%	54	94.7%	259	90.6%
Diuretic	24	28.6%	28	31.5%	18	32.1%	23	40.4%	93	32.5%
Warfarin	3	3.6%	1	1.1%	2	3.6%	1	1.8%	7	2.4%
Average No. Grafts	3.42		3.40		3.22		3.40		3.37	
CPS score-urgency										
Average	16.87		32.49		44.71		58.89		35.54	
Standard deviation	3.96		4.64		2.71		8.29		15.98	
Range	8 to 24		25 to 39		40 to 49		50-87		8 to 87	

Percentages are calculated excluding missing data

Figure 4 Statistical Analysis of Kaplan-Meier Curves

Comparison of survival curves (Logrank test)				
Endpoint: Observed n	6.0	6.0	7.0	1.0
Expected n	2.1	3.3	6.1	8.5
Chi-square	16.3184			
DF	3			
Significance	P = 0.0010			