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Functional Capacity After Cardiac Surgery in Elderly Patients

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Objectives. **This study was performed to determine whether cardiac surgery improves functional capacity in patients >70 years of age and to identify factors associated with good and poor functional results in this age group.**

Background. **Cardiac surgery has been used increasingly among older patients, but the effectiveness of surgery in this age group remains controversial.**

Methods. **Self-reported functional capacity was assessed by the Duke Activity Status Index preoperatively and again 1 year after coronary artery bypass or valve replacement surgery in a total of 199 patients with a mean age of 76 years (range 70 to 91).**

Results. **Functional capacity improved significantly after surgery (mean Duke Activity Status Index 27.9 at baseline vs. 36.8 at 12 months, $p < 0.001$), with improvements in most patients (74%). Six preoperative factors were independent predictors of less improvement in functional capacity between baseline and 1 year: smoking, female gender, higher Charlson comorbidity index, syncope, previous cardiac operation and older age. Postoperative complications were also a highly significant predictor of lower functional capacity at 1 year.**

Conclusions. **Most older patients have meaningful improvements in functional capacity after cardiac surgery, and clinical factors appear to modify the degree of improvement attainable.**

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The number of elderly patients undergoing invasive cardiac procedures has increased dramatically during the past decade. According to recent data from the National Center for Health Statistics, >134,000 coronary artery bypass graft procedures were performed in persons >65 years (1). In spite of frequent concomitant systemic diseases and other disabilities among older candidates for cardiac surgery, improvements in cardiopulmonary bypass and operative techniques allow cardiac surgery to be performed safely in the aged population (2–6). Although cardiac surgery can be performed in elderly patients, there remain questions about whether functional capacity can be improved sufficiently in such patients to justify the procedure. With the decrease in physiologic reserve among older patients, postoperative length of stay is increased, and complications are more frequent. Comorbidity may limit the capacity for improvement in functional capacity even after successful surgery for a cardiac abnormality. To evaluate this outcome in a sample of elders, we used the Duke Activity Status Index, a standardized self-report measure that correlates well with maximal oxygen uptake during exercise testing and before and 1 year after cardiac surgery (7,8).

Methods

A prospective cohort design was used to enroll 199 patients with a mean (±SD) age of 75.8 ± 4.6 years (range 70–91) from two teaching and four community hospitals in Northern California: Sequoia Hospital, Redwood City; Stanford University Medical Center, Stanford; Mills-Peninsula Hospital, Burlingame; St. Mary's Hospital, San Francisco; California Pacific Medical Center, San Francisco; and University of California, San Francisco. Patients were eligible if they were scheduled for coronary artery bypass graft or valve replacement surgery, or both, were at least 70 years old, were English speaking, could be contacted by telephone and passed a mental status test preoperatively and postoperatively (9). This study was approved by the institutional review boards of each hospital, and informed consent was obtained from each patient.

Research nurses in each hospital collected data prospectively with regard to admission symptomatology, preoperative cardiac and surgical history, presence of risk factors, New York Heart Association functional class and postoperative in-hospital course. Preoperative comorbid conditions were classified by the Charlson comorbidity index (10), a weighted score that takes into account the number and severity of comorbid diseases. Preoperative functional

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Table 1. The Duke Activity Status Index

Activity	Index Weight
Can you	
1. Take care of yourself, that is, eating, dressing or using the toilet?	2.75
2. Walk indoors, such as around your house?	1.75
3. Walk a block or two on level ground?	2.75
4. Climb a flight of stairs or walk up a hill?	5.50
5. Run a short distance?	8.00
6. Do light work around the house like dusting or washing dishes?	2.70
7. Do moderate work around the house like vacuuming, sweeping floors or carrying in groceries?	3.50
8. Do heavy work around the house like scrubbing floors or lifting or moving heavy furniture?	8.00
9. Do yardwork like raking leaves, weeding or pushing the lawn mower?	4.50
10. Have sexual relations?	5.25
11. Participate in moderate recreational activities like golf, bowling, dancing, doubles tennis or throwing a baseball or football?	6.00
12. Participate in strenuous sports like swimming, singles tennis, football, basketball or skiing?	7.50

status was assessed using the Duke Activity Status Index, a 12-item scale that assesses whether the patients can perform a spectrum of activities without difficulty. This index consists of questions on the patients' abilities to engage in self-care activities (one item), ambulation (four items), household work (three items), yard work (one item), sexual relations (one item) and recreational activities (two items) (Table 1).

One year after surgery, symptomatic status of the cohort as well as functional class, work status (if applicable) and the self-report of recovery (11) were reassessed by telephone, with contact by mail if necessary.

Statistical analysis. The paired *t* test was used to compare Duke Activity Status Index scores at baseline and at 1 year. Frequency distributions were used for the description of the sample, and one-way analysis of variance was used to compare functional capacity as a function of type of surgery. Hierarchic multiple regression analysis was used to assess the best predictors of baseline functional capacity. Change in functional capacity between baseline and 1 year was assessed through analysis of covariance, where the baseline Duke Activity Status Index score was partialed from the 1-year score, producing change as the conceptual dependent variable in a hierarchic multiple regression model (12). The assumption of no interaction between the variable being controlled for (preoperative Duke Activity Status Index score) and the other variables in the model was tested and found to be satisfied. A type I error rate of 0.05 was used for all analyses.

Table 2. Preoperative Clinical Characteristics of 199 Study Patients

	No. of Pts	%
Type of surgery		
CABG	123	62
Valve replacement	38	19
CABG and valve replacement	30	15
Age (yr)		
70–74	98	49
75–79	54	27
≥80	47	24
Reoperation	50	25
NYHA functional class		
I	21	11
II	70	35
III	68	34
IV	40	20
Admission symptoms		
Angina	135	68
Syncope	26	13
Nocturnal dyspnea	22	11
Exertional dyspnea	109	55
Medical history		
Heart failure	58	29
Peripheral edema	30	15
Previous infarct	54	27
Previous PTCA	26	13
Cancer	32	16
Risk factors		
Hypertension	101	51
Diabetes	30	15
High cholesterol	68	34
Smoking		
Ever	85	43
On admission	8	4
Ejection fraction < 50%	93	47
Three-vessel disease	64	32

CABG = coronary artery bypass graft; NYHA = New York Heart Association; PTCA = percutaneous transluminal coronary angioplasty; Pts = patients.

Results

A total of 199 patients were enrolled in the six study hospitals (Table 2). The majority of patients were men (74%), white (96%), married (70%) and well educated (only 15% had less than high school education; 40% had college experience; and 17% held postgraduate degrees). Most surgical procedures were elective (72%), with urgent and emergency procedures representing only 27% and 1%, respectively.

At baseline, significant comorbid disease, as defined by the Charlson comorbidity index, was present in 74% of the patients. A score of 1 was present in 66 patients (33%), 2 in 42 patients (22%), 3 in 29 patients (15%) and ≥4 in 10 patients (5%). Patients with greater degrees of comorbidity had significant reduction in functional status as measured by the Duke Activity Status Index (Fig. 1). Higher preoperative Duke Activity Status Index scores were also significantly

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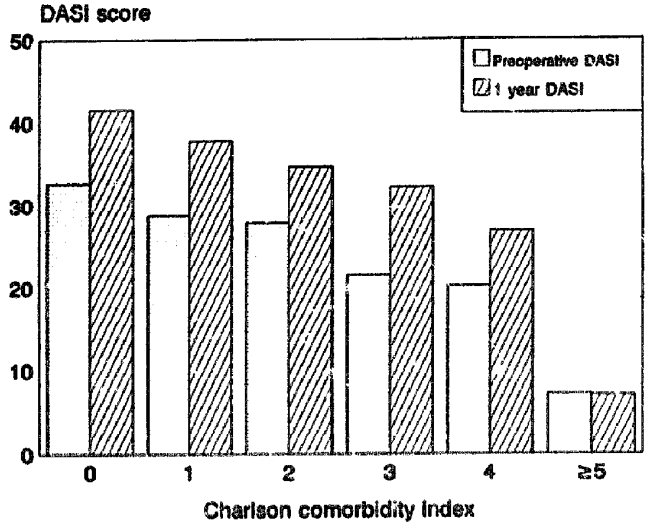


Figure 1. Mean Duke Activity Status Index (DASI) scores at baseline and 1 year postoperatively as a function of the Charlson comorbidity index.

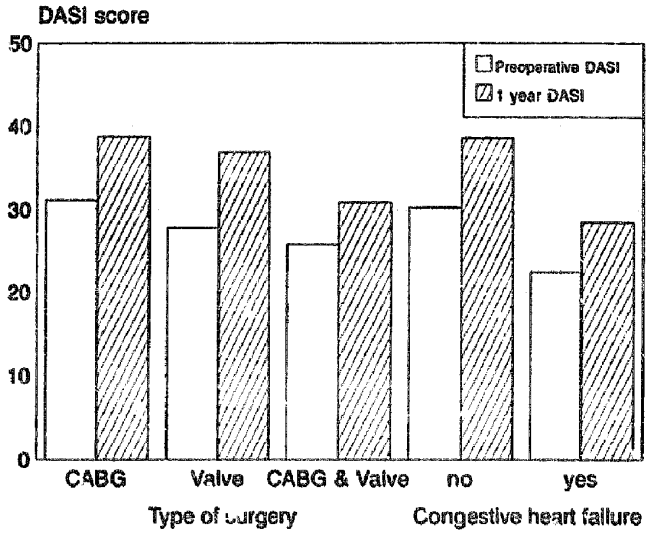
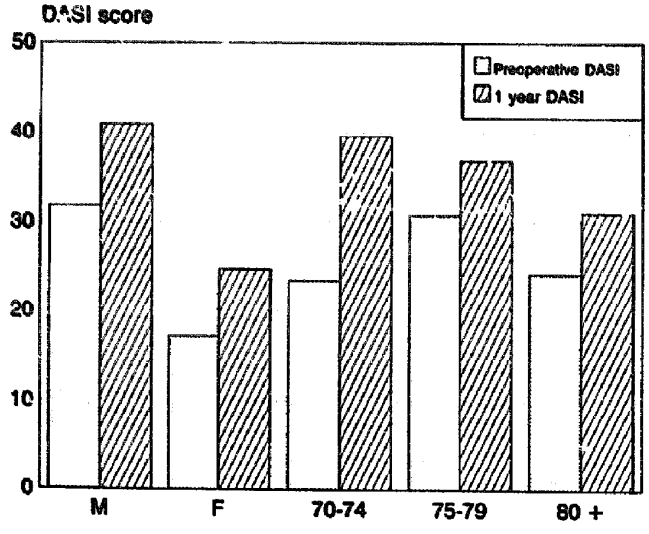


Figure 3. Mean Duke Activity Status Index (DASI) scores at baseline and 1 year postoperatively as a function of type of surgery and presence of congestive heart failure on admission. CABG = coronary artery bypass graft surgery.

correlated with male gender ($r = 0.419$, $p < 0.0001$), lower anginal status (functional class, $r = -0.174$, $p = 0.01$), absence of congestive heart failure ($r = -0.24$, $p = 0.0009$), lower Charlson comorbidity score ($r = -0.27$, $p = 0.0002$) and absence of dyspnea ($r = -0.21$, $p = 0.0062$) (Fig. 2 and 3). In a multiple regression model, only female gender and a higher Charlson comorbidity index were independently predictive of a lower Duke Activity Status Index score on admission.

Postoperatively, median stay in the intensive care unit was 3 days (25th and 75th percentiles were 2 and 5, respectively). The mean total length of hospital stay was 12.7 days.

Figure 2. Mean Duke Activity Status Index (DASI) scores at baseline and 1 year postoperatively as a function of age (in years) and gender. F = female; M = male.



Significant intraoperative and postoperative complications occurred in 49 (25%) of the patients, and 11 patients (5%) died within 30 days. Among the survivors, bleeding requiring reoperation (nine patients), heart block requiring permanent pacemaker (eight patients), stroke (seven patients) and mechanical support (four patients) were the most common complications.

Follow-up data at 1 year were available for 176 of the 199 patients. Follow-up was not available for 13 patients because of death, for three because of interval deterioration in mental status, for five because of patient refusal and for two because of loss to follow-up.

One year after surgery, most patients improved substantially in functional capacity (Table 3). Eighty-two percent of patients were functional class I in follow-up. Nearly all patients working preoperatively returned to work (13 [81%] of 16).

Medication use in the cohort also significantly decreased over time; at 3-month follow-up, relief of symptoms was reflected by a marked decrease in mean number and cost of cardiac drugs ($p < 0.001$). The most frequently deleted drug classes were nitrates and calcium-channel blocking, beta-adrenergic blocking and diuretic agents.

Table 3. Preoperative and Postoperative New York Heart Association Functional Class for 199 Study Patients

Preoperative Functional Class	Postoperative Functional Class				Deaths (n = 13)	Lost to Follow-Up (n = 10)
	I	II	III	IV		
I	15	2	2	0	2	0
II	58	5	1	1	4	2
III	42	10	4	1	7	4
IV	28	7	0	0	0	4

Table 4. Multiple Regression Summary Table Predicting Duke Activity Status Index at 1 Year of Follow-Up

Variable	Preoperative Model		Postoperative Model	
	Coefficient	p Value	Coefficient	p Value
Preoperative DASI	0.4	< 0.0001	0.4	< 0.0001
Smoking history*	−5.8	0.0001	−5.8	< 0.0001
Female gender†	−10.8	0.0002	−12.4	< 0.0001
Charlson index	−2.5	0.009	−2.2	0.02
Syncope†	−9.0	0.009	−7.4	0.02
Reoperation†	−6.4	0.02	−6.9	0.006
Age (yr)	−0.5	0.03	0.5	0.05
Complications†	NA		−10.0	< 0.0001
Constant	79.4		78.6	

*Smoking history coded as 1 for never, 2 for stopped >1 month before admission, 3 for stopped within 1 month before admission and 4 for smoking on admission. †Presence of factor coded 1; absence coded 0. DASI = Duke Activity Status Index.

The Duke Activity Status Index showed a substantial improvement in self-reported functional capacity after surgery, with a baseline average score of 27.9 versus 36.8 at 1 year ($p < 0.001$). This improvement is equivalent to a significantly higher exercise performance allowing moderate exertion, such as stair climbing or recreational activities.

Change in functional capacity over time was examined as a function of type of surgery (Fig. 3). Although there was a trend toward lower baseline and lower 1-year Duke Activity Status Index scores for the group of patients who underwent a combined procedure of coronary artery bypass graft and valve replacement, one-way analysis of variance comparing the three surgical procedures did not reveal significant differences among the groups.

Despite the overall improved functional status in the cohort, 45 (26%) of the 176 patients who remained active in the study (34 men, 11 women) had a lower Duke Activity Status Index score at 1 year than at baseline. The 13 patients who had died were assigned a Duke Activity Status Index of 0 at 12 months and were also included in the analysis. Predictors of change in functional capacity were assessed using a hierarchic multiple-regression model with the 12-month Duke Activity Status Index as the dependent variable. Preoperative Duke Activity Status Index score was entered in the first step, so that in subsequent steps the conceptual dependent variable was change in Duke Activity Status Index score between baseline and 1 year. In the second step, all baseline clinical factors available before the operation (Table 2) were considered potential variables to be entered in a stepwise fashion. In the final step postoperative complications were allowed to enter the model. Table 4 shows the regression summary. Seven variables were independent predictors of change in functional capacity: smoking status (on admission), gender, the Charlson comorbidity index, presence or absence of syncope on admission, reoperation, age and postoperative complications. After inclusion of these variables in the model, neither number of diseased vessels nor presence or absence of congestive heart failure added additional predictive information.

Discussion

The data reported here support the contention that the majority of older patients improve in physical function after cardiac surgery but that the increment in function decreases with smoking, female gender, comorbidity, a history of syncope and higher age. In addition, patients who underwent a second cardiac surgery procedure did not gain the same increment in function as those undergoing surgery for the first time. Finally, postoperative complications were a further factor contributing to decreased functional improvement at 1 year.

Surgery in the elderly. The overall clinical results in this series are comparable to other reports of cardiac surgery in elderly patients. Most patients (>70%) were in a stable preoperative condition and could be operated on electively. Thirty-day mortality was similar to that reported by other investigators, who have observed 5% to 10% early mortality rate for this age group (2–4,6,13). Hemorrhage was among the most frequent nonfatal complication (4.5%), and cerebral complications occurred in <4% of the patients, a rate comparable to other series (3,4). The improvement in functional class in the majority of patients confirms the effectiveness of cardiac surgery in elderly patients (3,4,14). However, evaluation of functional class alone does not capture functional limitations not related to cardiac disease that are common among elder patients. In a retrospective study Glower et al. (15) were among the first to document the overall performance status and outcome after coronary artery bypass graft in 86 patients aged 80 to 93 years. These investigators emphasize the need for comprehensive documentation of functional status in the elderly beyond angina relief because comorbid conditions are likely to compromise functional capacity despite improved cardiac status in this population. Using the Karnovsky score preoperatively and postoperatively, this study documented the increase in functional status in this elderly population. The Duke Activity Status Index used in our study may provide a more accurate picture of functional capacity because it was specifically developed and validated for a cardiac population and has been shown to correlate well with the reference standard for functional capacity minus maximal oxygen uptake during exercise testing.

Limits to functional recovery. In our study, female gender, comorbidity, repeat surgery, higher age, smoking history and postoperative complications were the primary contributers to a poor functional prognosis at 1 year after surgery (Table 4). The lesser improvement in functional capacity in women may be explained by several factors. The smaller size of women is associated with both smaller coronary arteries and valve rings, which may make the results of surgery less satisfactory. Also, women in this age group are often caregivers for their spouses, which may adversely

affect their own recovery from the procedure. Comorbidity reduces functional capacity independently of the severity of cardiac disease and may therefore limit the degree of improvement that a patient can expect after surgery. However, moderate degrees of comorbidity may still allow sufficient functional improvement to make surgery worthwhile (Fig. 1). Reoperation was a significant predictor of less functional recovery in this cohort. This finding may be explained either by physicians requiring a greater severity of illness before offering patients reoperation or by the greater technical difficulties of a second cardiac surgery.

Although we observed an overall improvement in functional capacity in this cohort of patients, even for those >80 years old (Fig. 2), the degree of improvement attained diminished with advancing age. We cannot determine from our data whether functional improvement is impossible above a particular age. Indeed, chronologic age alone should not be used as a sole criterion for decisions about surgery because the data presented have shown that carefully selected patients at advanced ages can benefit from surgery.

The importance of postoperative complications in determining functional capacity at 1 year of follow-up is not surprising. These complications may lead to permanent sequelae (i.e., stroke) or serve as markers for frailer patients with less physiologic reserve. Complications are useful as explanatory factors in the analysis of outcome, but this information is less useful for clinical decision making because it is unavailable preoperatively. The fact that other clinical factors are also independent predictors of functional capacity at 1 year indicates that an uncomplicated course is not in and of itself sufficient to guarantee an optimal functional outcome after surgery.

Study limitations. This study has several limitations. First, we included hospitals performing cardiac surgery in one area of the country, and although both university and community hospitals were included, we cannot be certain that these hospitals are representative of the nation as a whole. Second, we included only patients who were offered and accepted cardiac surgery. It is likely these patients were judged by their physicians to be good candidates for surgery and that these results should not be extrapolated uncritically to all patients ≥70 years old. Nevertheless, these findings support the contention that surgery can substantially improve functional capacity in selected older patients. Third, the Duke Activity Status Index is a self-report of functional capacity and not a direct measure of exercise performance. The Duke Activity Status Index has been validated against the reference standard of maximal oxygen uptake in younger patients but has not been separately validated in older patients. The responses to the question "can you perform an activity" (Table 1) on the Duke Activity Status Index scale are subjective and may be affected by patient factors and by method of administration. The degree of change observed in this study, however, is far more likely to have arisen from actual improvements in patient function than by an artifact of the measurement technique.

Conclusions. The present study suggests that cardiac surgery procedures in selected elderly individuals who have otherwise good physical and mental health can substantially increase functional status and quality of life.

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