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Coronary Artery Bypass Grafting in the Elderly: Pros and Cons after Three-year Follow-up

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Aim. The elderly represent an ever-growing proportion of the candidates for coronary artery bypass grafting (CABG) surgery. We analyzed the effect of anticipated risks on the early and mid-term outcome of coronary surgery in septuagenarians compared with younger patients.

Method. We analyzed 1,475 consecutive isolated CABG procedures performed at the Charles University Hospital during the 1995-1997 period and assessed their early and mid-term (3-year follow-up) results with respect to patient age. The patients were divided into two groups: younger (n = 1,324, age < 70 years) and older (n = 151, age ≥70 years). We studied potential preoperative risk factors, perioperative parameters, and postoperative course. Data on functional status, incidence of major cardiac events, and patient satisfaction with the outcome of surgery 3 years after the operation were collected from the patients by a questionnaire survey.

Results. The elderly had lower body mass index and body surface area, more advanced stage of disease according to the New York Heart Association and Canadian Cardiovascular Society classifications, higher prevalence of diabetes, renal dysfunction, and extracardiac arteriopathy. CABG was performed in both groups, with no procedural differences. The older group had higher mortality (7.3% vs 2.3%), incidence of NearMiss+ (outcome measure index; 36.4% vs 18.4%), and post-operative morbidity (56.3% vs 34.6%). Older patients also required longer stay at the intensive care unit and longer hospitalization. Three-year follow-up revealed identical relief of symptoms and improvement of functional status in both groups, with higher mortality in the elderly (15.3% vs 4.5%). The stroke was also more frequent in the elderly (8.6% vs 3.0%), whereas the occurrence of other non-fatal cardiac events was similar in both groups.

Conclusion. Coronary revascularization in the elderly carries higher but still acceptable risk. The elderly survivors showed similar functional improvement as the younger patients, but the actuarial survival was worse, mainly due to perpetuating cardiovascular illness. Surgical procedure should not be denied to elderly population based on age alone and each patient should be carefully evaluated.

Key words: *aged; coronary artery bypass; coronary disease; mortality; risk factors*

More than three decades have passed since the pioneering work of Favaloro, Garrett, Kolesov, and De Bakey (1). During that period the coronary artery bypass grafting has become a well-established method for effective relief of symptoms of ischemia and improvement of the long-term prognosis of the patients with coronary artery disease. The excellent results have encouraged the surgeons to offer the coronary artery bypass grafting procedure more frequently, especially to the elderly population (2-4). Although yielding similar benefits, the surgical revascularization in the elderly carries high incremental risks due to age-related morbidity and generally reduced vital capacity. The risks and benefits of surgery in elderly candidates for coronary artery bypass grafting deserve to be analyzed. The aim of our study was to validate the impact of main preoperative risk factors in elderly patients on the early and mid-term outcome of the coronary revascularization in comparison with the outcome in younger patients.

Patients and Methods

The entry criterion for the study was an isolated coronary artery bypass grafting performed on elective or urgent basis. The patients who underwent combined procedures (coronary artery bypass grafting and valve surgery, or repair of postinfarction ventricular septal defect, or left ventricle aneurysmectomy) were excluded.

Patients

A total of 1,584 coronary revascularization procedures were performed at the Department of Cardiac Surgery, Charles University Hospital, in the 1995-1997 period. From this cohort, 1,475 patients who underwent CABG as an isolated procedure were included in the study. The patients were divided into two age groups: the younger group included patients aged <70 years (n = 1,324) and the older group included patients aged ≥70 years (n = 151). The sample size allowed a 90% power to estimate the difference in overall mortality at the end of the follow-up.

Method

To assess the early outcome of coronary revascularization, we collected and analyzed three groups of data from the patients' medical histories: preoperative demographic parameters, prevalence of risk factors, and details of operative treatment and postoperative course. The data were retrieved from the Patient Analysis Tracking System Database provided by Medicon, Prague, Czech Republic, and completed with the data from the patient's medical documentation.

The data for mid-term follow-up were collected via a questionnaire mailed to all surviving patients three years after the operation. The queries concerned the self-appointed functional status of the patients according to the New York Heart Association (NYHA) and Canadian Cardiovascular Society (CCS) functional classification (*http://www.cochranfoundation.com/docs/nyha-class.htm*), re-occurrence of major cardiac events (myocardial infarction, stroke, recoronarography, or percutaneous cardiological intervention), satisfaction with the outcome of surgery (physical capability, relief of symptoms, and improvement of the general well-being). The response rate was 99% (several patients were surveyed via phone, information on patients who died was gathered from cardiologist's or general practitioner's files or hospitalization records; and 15 patients remained untraced).

Analyzed Data

We analyzed various parameters carrying a risk of poorer outcome of coronary revascularization.

Body mass index (body weight in kilograms/height in meters squared), which is associated with body fat, correlates with a risk of developing additional health problems (heart disease, diabetes, and hypertension). Body mass index over 25 is considered overweight and heralds a pro-atherogenic constitution (*http://www.nhlbi.nih.gov/guidelines/obesity/ob_gdlns.htm*).

Body surface area ($[weight^{0.425} \times height^{0.725}] \times 0.007184$) is a measure of stature (6). A small body surface area is a known risk factor of poor operative results (6).

NearMiss+ is a composite outcome index of a critical postoperative course for a patient who dies within 30 days, has cerebral damage not reversed by the time of discharge, requires dialysis, or spends more than 14 days in the hospital (*http://www.healthdataresearch.com/crp/webhelp/rmhelp/nearmiss__8.htm*). It is a sensitive measure of unsatisfactory results of the treatment, reflecting both the medical and economic impact.

NYHA and CCS functional classifications are based on the presence of dyspnea, palpitation and/or anginal pain (NYHA), or anginal pain only (CCS). Both divide cardiac patients according to their disability caused by cardiac disease into four classes: class I - patients with disease but without resulting limitations of physical activity or angina; class II - patients slightly limited by the symptoms during extensive physical strain; class III - patients suffering from considerable symptoms at a usual physical activity; and class IV - patients with symptoms present even at rest. A widely used and easily communicable measure of a cardiovascular functional status is a basic characteristic for the evaluation of the treatment.

Self-reported (via questionnaire) perception of one's own health (1 - excellent, 2 - very good, 3 - good, 4 - poor, and 5 - very poor), physical capability (1 - normal, 2 - slightly limited for cardiac reasons, 3 - moderately limited for cardiac reasons, 4 - severely limited for cardiac reasons, and 5 - limited for non-cardiac reasons), and improvement after operation (1 - much better, 2 - moderately improved, 3 - unchanged, 4 - much worse, and 5 - much worse) was a measure of subjective satisfaction with the outcome of the treatment. It was an equally relevant endpoint as objective clinical signs of successful operation.

We compared the paired values of the two groups by using two sample t-test and Fisher's exact test for contingency tables. The level of statistically significant difference was set at 0.05.

Results

Preoperative demographic characteristics and the data concerning the surgical procedure and postoperative course were analyzed. Significant differences were found between the groups in all three data categories.

Older patients had lower body mass index and body surface area than younger ones (Table 1). The prevalence of diabetes was higher among the elderly (41.7% vs 27.4%, $p \leq 0.05$), as well as the frequency of obliterative arteriosclerosis of peripheral vessels (20.5% vs 14.2%, $p = 0.05$). Renal dysfunction (as evidenced in a patient's medical file) was present in 19% of the elderly patients, compared with 11% in the younger group. The preoperative serum creatinine concentrations were also higher among the elderly (99.1 vs 90.5 μmol/L, $p \leq 0.006$). A more advanced stage of the coronary artery disease in the older patients was found according to both CCS (3.3 vs 2.8, $p \leq 0.001$) and NYHA (2.4 vs 2.2, $p = 0.001$) functional classification. Interestingly, the prevalence of current smokers was lower in the elderly (8.6% vs 21.2%, $p \leq 0.005$). There were no differences between the groups in hypercholesterolemia, hypertension, ejection fraction, history of transitory ischemic attack or stroke, previous myocardial infarction, and cardiological or cardiosurgical interventions (Table 1).

Table 1. Preoperative characteristics of the younger (<70 years, n = 1,324) and older (≥70 years, n = 151) patients undergoing coronary artery bypass grafting surgery[a]

Characteristics	Group of patients (No., %)		
	younger	older	p
BSA (mean ± SD, m^2)	1.94 ± 0.16	1.86 ± 0.16	<0.001
BMI (mean ± SD, kg/m^2)	27.5 ± 3.1	26.4 ± 3.2	<0.001
Diabetes mellitus (No., %)	363 (27.4)	63 (41.7)	<0.005
Renal dysfunction (No., %)	143 (10.8)	29 (19.0)	<0.005
Plasma creatinine level (mean ± SD, μmol/L)	90.5 ± 31.7	99.1 ± 26.5	0.006
Peripheral vascular disease	188 (14.2)	31 (20.5)	0.027
Current tobacco abuse	281 (21.2)	13 (8.6)	<0.005
History of TIA/stroke	65 (4.9)	12 (7.9)	NS
Hypertension	918 (69.3)	114 (75.5)	NS
Previous MI	948 (71.6)	110 (72.8)	NS
Previous cardiac surgery	58 (4.4)	4 (2.6)	NS
Previous cardiological intervention	128 (9.7)	19 (12.6)	NS
COPD	113 (8.5)	13 (8.6)	NS
Ejection fraction (mean ± SD, mL)	57.5 ± 14.0	56.4 ± 14.6	NS
Hypercholesterolemia (> 5.2 mmol/L)	729 (55.1)	80 (53.0)	NS
Hypercholesterolemia (> 7.7 mmol/L)	432 (32.6)	51 (33.8)	NS

[a]Abbreviations: BSA – body surface area; BMI – body mass index; TIA – transitory ischemic attack; MI – myocardial infarction; COPD – chronic obstructive pulmonary disease; NS – not significant.

Revascularization procedure was elective in 62% of the younger and 38% of the older patients (Table 2). Non-elective procedures included urgent transfer from the catheterization room, coronary artery bypass grafting performed because of severe/unstable angina, post-infarction angina or presence of critical coronary lesions during the hospitalization. No significant differences were found between the groups in the length of cardiopulmonary bypass, aortic cross-clamp, number of distal anastomoses, total blood loss, length of intubation, and the use of intra-aortic balloon pumping. The only difference found was longer extracorporeal circulation in the older group (81.3 vs 73.8 min, $p \leq 0.05$) (Table 2).

The 30-day mortality of all patients with isolated coronary artery bypass grafting was 2.9%. It was sig-

Table 2. Surgery and postoperative course in younger (<70 years, n = 1,324) and older (≥70 years, n = 151) patients undergoing coronary artery bypass grafting surgery[a]

Parameters	Group of patients (No., %) younger	older	p
Non-elective operation	507 (38.3)	93 (61.6)	<0.005
No. of distal anastomoses (mean ± SD)	2.6 ± 0.9	2.6 ± 0.8	NS
Aortic cross-clamp time (mean ± SD, min)	44.7 ± 15.7	44.6 ± 16.5	NS
Length of CPB (mean ± SD, min)	73.8 ± 30	81.3 ± 35	<0.041
IABP - after weaning off CPB	27 (2)	4 (2.6)	NS
30-days mortality	31 (2.3)	11 (7.3)	0.002
NearMiss +	244 (18.4)	55 (36.4)	<0.001
Postoperative complications	458 (34.6)	85 (56.3)	<0.005
Total blood loss (mean ± SD, mL)	1,031 ± 787	1,055 ± 853	NS
Transfusions of PRC (mean ± SD, units)	2.16 ± 2.5	3.25 ± 2.8	0.001
Median length of intubation (range, h)	17 (0-1,776)	20 (1-280)	NS
Length of stay in ICU (mean ± SD, h)	56.3 ± 86.4	66.0 ± 48.5	0.037
Length of hospital stay (mean ± SD, days)	11.8 ± 5.4	13.1 ± 6.4	0.006

[a]Abbreviations: NS – not significant; CPB – cardio-pulmonary bypass; IABP – intraaortic balloon pumping; PRC – packed red cells; ICU – intensive care unit.

Table 3. Postoperative complications in younger (<70 years, n = 1,324) and older (≥70 years, n = 151) patients undergoing coronary artery bypass grafting surgery

Type of complication	Group of patients (No., %) younger	older	p
Renal	70 (5)	23 (15)	> 0.001
Neurological	43 (3)	11 (7)	0.017
Amentia/psychical deterioration	30 (2)	11 (7)	0.002
Pulmonary	130 (10)	19 (13)	NS[a]
Ventricular fibrillation - defibrillated	17 (1)	8 (5)	0.002
Postoperative atrial fibrillation	86 (6)	20 (13)	0.004
Other postoperative dysrythmias	70 (5)	18 (12)	0.002
Q-wave myocardial infarction	32 (2)	5 (3)	NS
Non-Q myocardial infarction	13 (1)	4 (3)	NS
Low cardiac output	71 (5)	17 (11)	0.006
Coagulation disorders	15 (1)	3 (2)	NS
Hypertension postoperative	25 (2)	9 (6)	0.005
Pancreatitis	9 (1)	7 (5)	0.001
Hepatobilliary	15 (1)	5 (3)	0.045
Revision for bleeding	37 (3)	6 (4)	NS

[a]NS – not significant.

nificantly higher in elderly patients (7.3% vs 2.3%, p = 0.002), as well as the incidence of NearMiss + (36.4% vs 18.4%, p≤0.001) and postoperative complications (56.3% vs 34.6%, p≤0.005). Renal failure, neurological and neuropsychological disorders, arrhythmias, and low cardiac output were the complications strikingly more pronounced in the elderly group (Table 3). Older patients required more transfusions of autologous blood (3.3 vs 2.2 blood units, p = 0.001) and stayed longer at intensive care unit (66.0 vs 56.3 h, p≤0.04). The mean length of hospital stay after operation was also longer in older patients (13.1 vs 11.8 days, p≤0.006) (Table 2).

Three years after the operation, the patients were asked to grade their CCS and NYHA status, provide subjective evaluation of their health in general on a 5-grade scale (from "excellent" to "very poor"), compare their condition with preoperative status (5 grades, from "much better" to "much worse"), and qualify their physical capability (5 grades, from normal to markedly limited due to cardiac/non-cardiac reasons). Both groups showed consistent functional improvement for more than one class according to both CCS and NYHA classifications (Table 4). Also, the diversification of self-reported markers of satisfaction was almost identical in both groups (Table 4).

Table 4. Canadian Cardiovascular Society (CCS) functional classification, New York Heart Association (NYHA) functional classification, and self-reported satisfaction with the outcome of surgery in younger (<70 years, n = 1,218) and older (≥70 years, n = 117) patients responding to a questionnaire survey 3 years after coronary artery bypass grafting

Classification	Group of patients (No., %) younger	older	p
CCS (mean ± SD)	1.3 ± 1.2	1.5 ± 1.2	NS[a]
NYHA (mean ± SD)	1.5 ± 1.0	1.6 ± 1.1	NS
Subjective improvement of health status after coronary artery bypass grafting:			
1-much better	664 (55)	72 (62)	NS
2-moderately improved	320 (26)	27 (23)	NS
3-unchanged	143 (12)	7 (6)	0.034
4-slightly worse	77 (6)	8 (7)	NS
5-much worse	11 (0.9)	2 (2)	NS
not answered	3 (0.2)	0	–
Self-estimated quality of health:			
1-excellent	25 (2)	4 (3)	NS
2-very good	144 (12)	13 (11)	NS
3-good	882 (72)	83 (71)	NS
4-poor	162 (13)	16 (14)	NS
5-very poor	4 (0.3)	1 (1)	–
not answered	1 (0.1)	0	–
Self-estimated physical capability:			
1-normal	239 (20)	27 (23)	NS
2-slightly limited from cardiac reasons	306 (25)	27 (23)	NS
3-moderately limited from cardiac reasons	385 (32)	30 (26)	NS
4-severely limited from cardiac reasons	89 (7)	6 (5)	NS
5-limited from non-cardiac reasons	196 (16)	27 (23)	0.039
not answered	3 (0.2)	0	–

[a]NS – not significant.

During the follow-up, 23 (15.2%) late deaths occurred in the elderly group, resulting in an overall three-year survival rate of 77.5% (operative mortality included), compared with 60 late deaths (4.5%) and a survival rate of 93.2 % in the younger group (operative mortality included, p<0.001) (Table 5, Fig. 1).

Table 5. Late death and reoccurrence of major cardiac events in younger (<70 years, n = 1,324) and older (≥70 years, n = 151) patients during 36-month follow-up after coronary artery bypass grafting surgery

Findings	Group of patients (No., %) younger	older	p
Late death/36 months	60 (4.5)	23 (15.2)	<0.001
Causes of death:			
myocardial infarction	23 (1.7)	9 (6.0)	<0.003
heart failure	5	3	–
stroke	7	3	–
tumor	7	3	–
sepsis	1	2	–
trauma	3	0	–
aortic dissection	2	0	–
sudden death	0	1	–
other	7	2	–
unknown	5	0	–
Non-fatal myocardial infarction	37 (2.8)	4 (2.6)	NS
Non-fatal stroke	40 (3.0)	13 (8.6)	<0.001
Recoronarography	143 (10.8)	14 (9.2)	NS
Percutaneous coronary intervention	63 (4.8)	7 (4.6)	NS

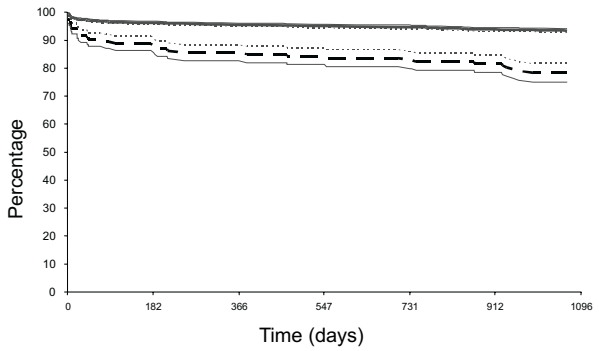

Figure 1. Kaplan-Meier's analysis of actuarial survival of the patients 3 years after coronary artery bypass grafting showed significant difference between the younger (aged <70 years, n=1,324; full line) and older (aged ≥70 years, n=151; dashed line) patients (p<0.001). Dotted line – standard deviations.

The two groups did not differ in the incidence of recurrent non-fatal myocardial infarction, recoronarography, and percutaneous coronary intervention. However, a significantly higher occurrence of a stroke (8.6% vs 3.0%, p<0.001) was recorded in the elderly group.

The annual incidence of hospital readmission for cardiac reasons was analyzed for each group (Fig. 2). The need for rehospitalization of younger patients significantly and consistently decreased during the 3-year follow-up period (from 9.6% to 4.1 %, p<0.001), whereas the incidence of rehospitalization in the elderly, ranging between 7.8% and 12.1%, did not significantly change. Only incidental difference in annual rehospitalization rate was found between the groups.

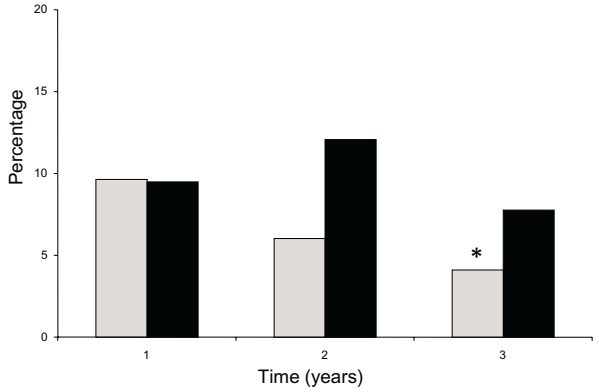

Figure 2. The incidence of hospital readmissions of patients after coronary artery bypass grafting during the 3-year follow-up period. No consistent differences were found between the younger (aged <70 years, n=1,324; grey bars) and older (aged ≥70 years, n=151; closed bars) patients. Asterisk indicates p=0.01 vs younger patients at 1 year follow-up.

Discussion

Coronary artery bypass grafting, today a fully standardized and highly effective method, is used for the treatment of seriously ill patients suffering from a generalized arteriosclerosis. The spectrum of candidates for coronary artery bypass grafting has been changing unfavorably: low-risk patients preselected by cardiologists for interventional treatment are being replaced by an ageing population of patients with advanced and complex comorbidities. Once the stenotic coronary bed has been confirmed by a diagnostic coronarography, even very old people are likely to be referred for cardiac surgery.

Higher risks of coronary artery bypass grafting in the elderly patients have been recognized since the beginnings of routine cardiac surgery (7-8). Continuous refinement of operative techniques, optimization of the cardio-pulmonary bypass, and sophistication of postoperative care have constantly counterbalanced the obvious fragility of aged population. Thus, cardiac surgery turned out feasible even in patients in a very advanced age (9). Nevertheless, the decision about revascularization in highly symptomatic elderly patients has remained a challenge for the surgeon who neither wants to deny effective treatment to symptomatic patients nor can ignore the results of the surgery (10-11).

Our study analyzed the outcomes of coronary artery bypass grafting in the elderly in the Czech Republic, a post-socialist country with a steep increase in the number of cardiovascular diagnostic and treatment procedures during the recent decade (12,13). Unlike the population in developed western countries, aware of the risks of arteriosclerosis, the Czech population of the early 1990s was characterized by an unhealthy life style and shortened lifespan due to high cardiovascular mortality (14). The long-term impact of such historical and socio-economic factors is reflected today in the clinical conditions of our patients-candidates for coronary artery bypass grafting.

Due to the presence of recognized and important risk factors (advanced stage of NYHA and CCS, diabetes mellitus, manifestations of extracardiac obliterative arteriosclerosis, or renal dysfunction) in elderly candidates for coronary artery bypass grafting, we expect the outcome of the surgery in these patients to be worse. The advanced stage of cardiac disease is mainly a consequence of its longer duration and partly of the previous postponement of radical treatment in otherwise risky patients, and has led to the higher percentage of urgent, non-elective coronary artery bypass grafting procedures. In our study, the prevalence of diabetes was significantly higher in the elderly and this comorbidity could have multiple negative effects, such as advanced morphologic changes in coronary arteries, renal dysfunction or impaired wound healing. With regard to the age of the candidates for coronary artery bypass grafting, diabetes is more frequent in septuagenarians and less frequent in studies in octogenarians and older patients (11). This phenomenon is probably caused by a careful selection of octogenarians for coronary artery bypass grafting treatment, as well as a reduced life span of diabetic patients (11).

Older patients in our study had lower body surface area and body mass index. Smaller body surface

area is a known risk factor of poor operative results, mainly because it means small vessel diameter in general, but its interaction with body mass index value (the higher level of which in the younger patients heralds the pro-atherogenic constitution) remains speculative (6).

Renal dysfunction is another potent factor jeopardizing the outcome of surgery in elderly patients. The pre-existing diminished renal capacity, together with adverse effects of low cardiac output, also more frequent in the elderly, set the ground for significantly higher occurrence of postoperative renal disorders in older patients.

We found no significant differences between the groups in other important preoperative markers linked to cardiovascular or overall morbidity, such as the history of transitory ischemic attack or stroke, hypertension (both showing a slight trend to higher incidence in the elderly), previous myocardial infarction, cardiological intervention or cardiac surgery, decreased ejection fraction, chronic obstructive pulmonary disease, and hypercholesterolemia. The probable explanation lies in the fact that patients referred and accepted for cardiac surgery are a subpopulation selected by cardiologists and cardiac surgeons, when there is a reasonable presumption of a benefit from the procedure. The elderly with chronic obstructive pulmonary disease, stroke, or low ejection fraction are most often referred for pharmacological or percutaneous coronary intervention, rather than surgery. The absence of differences in other preoperative characteristics (hypertension and hypercholesterolemia) seems difficult to interpret because of the sample size.

With regard to a cluster of known risk factors, it is not surprising that the 30-day mortality in our group of elderly patients who underwent coronary artery bypass grafting was significantly higher than in the younger patients. Similarly, the incidence of Near-Miss+ was two-fold higher in the elderly group. These findings correlate with the results of the similar studies performed in the western countries (15,16). Thus, since there were no obvious differences in operative strategy or technique (with the exception of the duration of cardio-pulmonary bypass, which was slightly longer in the elderly group), the worse results seem to be attributable to higher preoperative comorbidity and age-related diminished functional capacity of the septuagenarians. The overall fragility of these patients is clearly documented in a wide spectrum of postoperative complications, more frequent in the elderly. In our study, the most pronounced were renal failure, neurological and neuropsychical disorders, low cardiac output, and arrhythmias.

However, our analysis of mid-term results revealed that the surviving elderly patients are equally satisfied with an improved well-being, relief of symptoms, and preserved physical capability as the younger patients, which is in accordance with other studies (15,16). Similarly, the incidence of new non-fatal myocardial infarction and the need of recoronarography or percutaneous coronary intervention in our groups of patients were not significantly different. The stroke was the only major cardiovascular event that was more frequent in the elderly.

The most frequent cause of late death in both groups of our patients was myocardial infarction and/or heart failure, with incidence nearly 3.5-fold higher in elderly patients. However, the higher rate of late cardiac deaths should not mask the benefit of coronary artery bypass grafting in the elderly, because it leads to functional improvement and relief of symptoms of ischemic heart disease.

In conclusion, our data support the hypothesis that the older age of the candidates for coronary artery bypass grafting is a marker of elevated risks and worse results of the surgery due to higher pre-operative comorbidity and generally decreased vital capacity, regardless of continuous refinement of operative techniques and accumulation of knowledge in cardiac surgery. The active approach to the treatment of the elderly is not merely a domain of health professionals but it also sensitively reflects the moral and material evolution of the whole society.

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