Chapter 52
Cardiac Surgery in the Elderly

Margarita T. Camacho and Pooja R. Raval

As the elderly population steadily rises each year, so does the number of patients referred for cardiac surgical procedures. The U.S. Census Bureau predicted that there would be approximately 7.4 million people over the age of 80 by 2008, as compared to 6.2 million in 2000 [1]. Recent data reported that elderly patients over the age of 70 with no functional limitations could expect to live 14.3 years longer, compared with 11.6 years for those with limitation in at least one activity of daily living [2]. A formidable challenge facing cardiologists and cardiac surgeons is the appropriate treatment of the 40% of a growing elderly population that suffers from symptomatic cardiovascular disease [3]. The morbidity and mortality associated with cardiac surgical procedures in the elderly has substantially decreased since the late 1980s [4], although it is still higher than that of younger counterparts less than 70 years of age [5]. Reports of acceptable mortality rates and improved long-term quality of life justify cardiac operations in most symptomatic elderly patients. Only recently large studies have focused on risk analyses and outcomes in an effort to provide the clinician with as much evidence-based literature as possible to make the most appropriate decisions for many of these complex elderly patients.

Characteristics of the Elderly Cardiac Surgery Population

Despite the lack of consensus regarding the definition of "elderly," the perioperative cardiac surgery mortality rates rise significantly in patients older than 75 years of age [6]. An individual older than age 80 has more than three times the risk of death after coronary artery bypass than does a similar 50-year-old patient [7]. The increased risks of death and major complications are due not only to the natural processes of aging that result in associated comorbidities, but also to the fact that cardiovascular disease, the major cause of death and disability among elderly patients, is diagnosed at a more advanced state in this old population.

The aging process is influenced by a variety of genetic and environmental factors and occurs at somewhat different rates in every individual. The older the patient, the more likely is the presence of multiple chronic noncardiac diseases, increased tissue fragility, and limited organ reserves for stressful events [7]. Postoperative complications such as pneumonia, renal failure, stroke, and dementia are more prevalent and contribute significantly to perioperative morbidity and mortality. More than 50% of elderly individuals have at least one or more chronic medical conditions [8]. In addition to the routine preoperative assessment, other issues that must be evaluated include the degree of cognitive, neurologic, renal, respiratory, and immune impairment and the presence of other noncoronary atherosclerosis. Approximately one in three patients older than age 80 has some degree of cognitive dysfunction [9], and it is important to establish a baseline level of performance prior to surgical intervention [10]. Tests with age-specific normative standards include the Wechsler Adult Intelligence Scale, the Controlled Oral Word Association, and the Multilingual Aphasia Examination [11]. Patients with previously compromised cognitive function are at highest risk for such postoperative complications as delirium and progressive cognitive dysfunction. Depression is a common problem in patients of all ages and has been reported to follow cardiac surgery. It is clearly more pronounced in the elderly patient who may live alone and have few social support systems.

By age 80, there is a 25% decrease in kidney mass and 40% reduction in glomerular filtration rate (GFR) [10]. Due to the decrease in lean muscle mass, a decrease in GFR may not be reflected by an increase in serum creatinine concentration, and therefore a "normal" creatinine level in an octogenarian may be misleading. A more useful assessment of renal

M.T. Camacho (✉)
Department of Cardiothoracic Surgery, Newark Beth Israel Medical Center, Newark, NJ, USA
e-mail: mcamacho@sbhcs.com

R.A. Rosenthal et al. (eds.), *Principles and Practice of Geriatric Surgery*,
DOI 10.1007/978-1-4419-6999-6_52, © Springer Science+Business Media, LLC 2011

function in the elderly patient is the age-related creatinine clearance (Ccr)

$$\text{Ccr (ml/min)} = \frac{(140 - \text{Age}) \times (\text{Ideal body weight in kilograms})}{72 \times \text{Serum creatinine}},$$

where normal is 75–125 ml/min. Renal function should be evaluated both before and after cardiac catheterization, and the amount of renally excreted dye used during angiography should be kept to an absolute minimum, employing nonionic contrast materials. The transient episodes of hypotension that inevitably occur during cardiopulmonary bypass may worsen any preexisting renal dysfunction; in this age group, perioperative renal insufficiency is a strong positive predictor of postoperative mortality [6, 12–14].

Old patients have declining cellular immunity and are therefore more predisposed to developing invasive bacterial and viral infections [10]. In addition to the bacterial colonization of the respiratory, urinary, and gastrointestinal tracts, there is a risk of infection from other monitoring lines and catheters used during cardiac surgery, such as central lines, Swan–Ganz catheters, and mediastinal drainage tubes. Leukocytosis is frequently absent or depressed in an elderly patient, who otherwise commonly exhibits atypical signs of infection such as hypothermia or confusion. Although most cardiac surgery patients are not cachexic or nutritionally depleted owing to their cardiac disease, it is important to assess the preoperative nutritional status of an elderly individual whose other organ reserves are already limited. Adequate nutrition is vital for wound healing and for avoiding infection and ventilatory dependence. Ideally, the serum albumin concentration should be >3.5 mg/dl, and there should be no history of recent significant (>5%) weight loss.

Numerous physiologic changes affect the cardiovascular system with advancing age. There is a decrease in vascular elasticity: The aorta and large arteries become much less compliant, resulting in an increase in peripheral vascular resistance. Left ventricular stiffness is increased [15], as is the ventricular septal thickness [16], and may require higher filling pressures to maintain adequate forward flow. During exercise there is a decrease in peak heart rate and ejection fraction, likely due to reduced responsiveness to circulating catecholamines [17–19]. Autopsy studies of octogenarians revealed that atherosclerotic heart disease with more than 75% narrowing in at least one major coronary vessel was the most common abnormality (present in 60% of patients). In fact, coronary disease was the most common single cause of death, with the most frequent manifestation being acute myocardial infarction [16]. Finally, compared with younger age groups, the heart of the elderly individual has smaller ventricular cavities and tortuous coronary arteries [20–22]. In light of these morphologic findings, it is not surprising that by age 80 at least 20% of this population have an established clinical diagnosis of coronary artery disease, and that eventually 67% of elderly patients die from this disease.

Elderly patients tend to have more advanced coronary artery disease than their younger counterparts by the time they are referred for cardiac surgery. Compared with the Coronary Artery Surgery Study (CASS) with a patient population of mean age 68 years [23], octogenarians were found to have a higher incidence of three-vessel coronary disease (87% vs. 61%; $p<0.05$), left main or left main-equivalent disease (50% vs. 3%, $p<0.0001$), and significant left ventricular dysfunction (19% vs. 4% had an ejection fraction <35%, $p<0.01$) [24]. Older patients are more symptomatic on presentation; many series report that more than 90% of octogenarians are New York Heart Association (NYHA) functional class III–IV preoperatively [13, 25–31]. When compared with younger patients, a significantly higher percentage of elderly patients are referred for more urgent or emergent procedures, which carry substantially increased risks of major morbidity and mortality [7, 13, 24, 29, 31–34]. This underscores the need to prevent emergent and urgent surgical interventions.

A common finding in elderly patients is calcification and intimal disease of the aorta, which can crack and embolize when the ascending aorta is clamped or manipulated during cardiac operations. Such embolization to cerebral vessels is the principal cause of perioperative stroke in this age group [35]. Other causes of surgery-related neurologic deficits include transient episodes of systemic hypotension during cardiopulmonary bypass and air embolism from procedures that necessitate opening cardiac chambers or great vessels, such as aortic or mitral valve operations. Although aortic valve calcification is present in more than 55% of patients over the age of 90, only 5% eventually develop significant hemodynamic valvular stenosis [36]. One important difference between aortic and mitral valve disorders in the elderly is that aortic valve disease is usually associated with preserved left ventricular function, whereas mitral valve disease in the elderly is often ischemic in nature and is associated with significant ventricular dysfunction. Davis et al. [37] noted that only 29% of elderly patients with significant aortic valve disease had concomitant disease of two or more coronary vessels, compared with 46% of patients with significant mitral valve disease.

Predictors of Perioperative Morbidity and Mortality

As experience with the surgical treatment of cardiac disease in septuagenarians has grown, the literature has focused on the surgical outcome in octogenarians (Table 52.1). Many of these studies have reported predictors of perioperative morbidity

Table 52.1 Cardiac surgical procedures in the octogenarian: results and average length of hospital stay

Study	Year	No.	Procedure	Mortality (%)	Complication rate (%)	Mean postoperative LOS	% Survival (years)
Deiwick et al. [34]	1997	101	Mixed	8	73		88 (1)
							73 (5)
Gehlot et al. [38]	1996	322	AVR mixed	14	53	11.0	83 (1)
							60 (5)
Sahar et al. [39]	1996	42	Mixed	7	24		
Logeais et al. [40]	1995	200	Mixed	12	35	12.7	82 (1)
							75 (2)
							57 (5)
Cane et al. [12]	1995	121	Mixed	9	49		
Klima et al. [41]	1994	75	Mixed	8	21		
Yashar et al. [42]	1993	43	Mixed	9	38		
Glower et al. [26]	1992	86	CABG	14	29	10.0	64 (3)
Freeman et al. [31]	1991	191	Mixed	20	30	16.4	92 (1)
							87 (2)
							82 (3)
							78 (4)
Tsai et al. [43]	1991	157	CABG	7	20		85 (1)
							62 (5)
Ko et al. [28]	1991	100	CABG	12	24		
Mullany et al. [44]	1990	159	CABG	11	73		84 (1)
							71 (5)
Naunheim et al. [33]	1990	103	Mixed	17	71		90 (1)
Kowalchuk et al. [45]	1990	53	Mixed	11	38		81 (2)
Fiore et al. [46]	1989	25	Mixed	20	72	18.0	79 (1)
			Valve				69 (2)
Naunheim et al. [24]	1987	23	Mixed	22	67	14.3	94 (1)
							82 (2)
Rich et al. [47]	1985	25	Mixed	4	92	19.5	84 (2)

Mixed series includes valve and coronary bypass procedures and/or valve + coronary bypass procedures; *AVR* aortic valve replacement, *CABG* coronary artery bypass grafting, *LOS* length of stay in hospital

and mortality based on extensive univariate and multivariate analyses. This information has proved vital in identifying specific factors that may be optimized preoperatively and has provided physicians and patients with the ability to make timely treatment decisions based on expected short-term and long-term outcomes.

Several studies have shown that a decreased ejection fraction is a significant predictor of hospital mortality following cardiac surgery. This is even more predictive of an adverse outcome in octogenarians. A number of series have reported hospital mortality rates of 3–6, 5–13, and 24–43% in patients with normal, moderately impaired, and severely impaired (ejection fraction < 0.30) left ventricular function, respectively [48–50]. In a multivariate analysis of factors involving 159 octogenarians who underwent isolated coronary artery bypass, Mullaney et al. [44] found that an ejection fraction less than 0.50% was the most important predictor of adverse survival ($p < 0.01$). Ko and coworkers, who analyzed 100 consecutive octogenarians undergoing isolated coronary artery bypass, also found a decreased ejection fraction to be the most significant predictor of perioperative mortality ($p < 0.002$). In fact, an ejection fraction less than 30% was associated with a mortality rate of 43% [28].

High NYHA functional cardiac class was highly predictive of hospital mortality in numerous studies [13, 16, 19, 22, 25, 26, 31, 45] In their series of 76 octogenarians undergoing a variety of cardiac surgery procedures, Tsai et al. [48] found that 94% of the hospital deaths were in patients who presented in NYHA functional class IV. In a study of 24,461 patients 80 years and older who underwent isolated coronary artery bypass, measures of more acute coronary disease, such as acute myocardial infarction (MI) before bypass surgery, predicted higher procedural and long-term mortality rates [49]. This relation with acute coronary artery disease has been borne out by numerous other authors [24, 26, 28].

Combined coronary surgery procedures and mitral valve replacement (MVR) have been shown to carry significantly higher hospital mortality rates in the elderly population [19, 27, 32, 36, 37, 39, 42, 45]. In the early 1990s, Davis and coworkers reported operative mortality rates of 5.3% for aortic valve replacement (AVR), 20.4% for MVR, and 5.8% for isolated coronary artery bypass [37]. Several years earlier, Naunheim et al. reported even higher hospital mortality rates of 50% for MVR, 9% for AVR, and 67% for double valve replacement combined with coronary revascularization [33]. More recent outcomes for those aged 75

Table 52.2 Comparison of mortality rates by procedure status (elective vs. urgent vs. emergent)

				Mortality (%)			
Study	Year	No.	Procedure	Overall	Elective	Urgent	Emergency
Diewick et al. [34]	1997	101	Mixed	7.9	4.7		23.5
Williams et al. [13]	1995	300	CABG	11.0	9.6	11.0	33.3
Diegeler et al. [29]	1995	54	Mixed	9.2	6.1		40.0
Freeman et al. [31]	1991	191	Mixed	18.8			35.9
Ko et al. [28]	1991	100	CABG	12.0	2.8	13.5	33.3
Naunheim et al. [32]	1990	103	Mixed	16.5		10.0	29.0
Naunheim et al. [24]	1987	23	Mixed	22.0	11.0		75.0

See Table 52.1 for explanation of abbreviations

and above at Newark Beth Israel Medical Center, a participant in The Society of Thoracic Surgeons 2004–2008 database, reveal mortality rates of only 4.8% for isolated AVR, 0% for isolated MVR, and 3.0% for isolated CABG (personal communication).

The outcome after valve replacement in elderly patients is primarily a function of the myocardial performance, which decreases as the severity of any associated coronary artery disease increases. Old patients undergoing AVR tend to have a well-functioning ventricle; the degree of coronary artery disease tends to be less than that in patients undergoing MVR. Patients requiring mitral valve surgery tend to have more serious ischemic disease, which can irreversibly damage the myocardium and result in higher perioperative mortality [20–22, 27]. Furthermore, combined procedures require longer cardiopulmonary bypass times and longer ischemic cross-clamp times, two factors that are predictors of operative mortality as well [19, 24, 26, 28].

In addition to presenting with more advanced disease than their younger counterparts, a higher percentage of octogenarians are referred for urgent or emergent surgical intervention. As noted in Table 52.2, urgent and emergent operations are associated with extremely high mortality rates, particularly if a mitral valve procedure is performed independently or in combination with other procedures. These increased mortality rates reflect the progression and severity of the cardiac disease and the lack of functional reserve for stressful events in this older population. Another related factor, preoperative hemodynamic instability, was described by several authors as the need for an intra-aortic balloon pump (IABP) [15, 19, 24, 25, 33, 39], preoperative admission to the coronary care unit [34, 38, 44], and preoperative use of inotropes and vasoactive medications [33, 50]. Each was found to be a significant predictor of hospital mortality. Multivariate analyses by Williams and coworkers, who studied a group of 300 octogenarians who underwent isolated coronary artery bypass, revealed that preoperative renal dysfunction (creatinine > 2.0 mg/dl), pulmonary insufficiency, and postoperative sternal wound infection were strong predictors of hospital mortality [13]. Tsai and coworkers found that 67% of the elderly patients with postoperative mediastinal bleeding necessitating reoperation ultimately died [48].

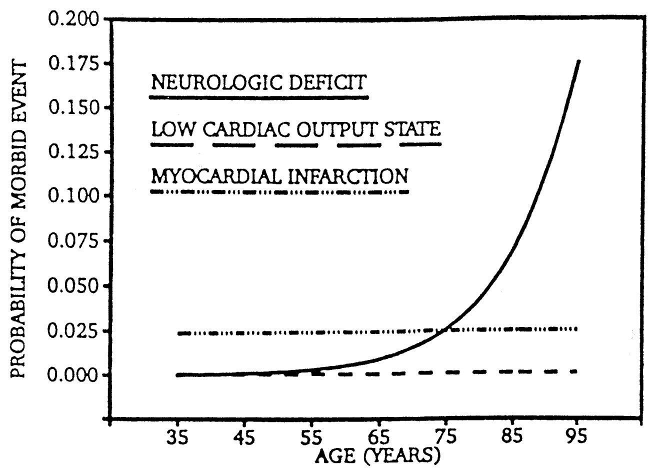

Figure 52.1 Effect of advanced age on the predicted probability of neurologic and cardiac morbidity (from Tuman et al. [51], with permission).

In a prospective study of 2,000 patients undergoing coronary artery bypass, Tuman et al. [51] studied the effect of age on neurologic outcome. The rate of neurologic complications rose significantly with age; patients <65 years old had a 0.9% stroke rate, whereas those aged 65–74 and >75 had rates of 3.6 and 8.9%, respectively ($p = 0.0005$). Suspected causes of serious neurologic events (in patients unresponsive for more than 10 days) include atheromatous emboli from the ascending aorta, hypotension or low-flow state during cardiopulmonary bypass, and preexisting critical extracranial or intracranial cerebrovascular disease. The mortality rate in this group of patients who sustained significant strokes was 74% (Fig. 52.1) [51]. Perioperative mortality associated with perioperative stroke in younger patients, although still formidable, was less than half of this frequency (24–26%).

Quality of Life

Although the short-term and intermediate-term survival for elderly patients undergoing cardiac surgery is somewhat less than their younger cohorts, the long-term survival for octogenarians after open heart surgery compares favorably with survival for the general US population of similar age. In a series of 600 consecutive patients 80 years or older undergoing various open heart procedures, the 5-year actuarial survival, including hospital mortality, was 63 ± 2%. Survival in this group was identical to that for the simultaneous general US octogenarian population [14]. Excellent long-term results have been achieved by several groups in octogenarians after mitral valve surgery, aortic valve surgery, and coronary artery bypass surgery [40, 52, 53].

Of as great importance to the elderly as survival is the associated quality of life. Several authors have shown that most (81–93%) of the octogenarians who survive open heart surgery "feel" as good and frequently better than before their operations [14, 29, 40, 53]. An equally high percentage (75–84%) of octogenarians believed in retrospect that having decided to have a cardiac surgical procedure after age 80 had been a good choice [14, 54]. The precise and objective measurements of quality of life may be difficult to quantify. Based on well-studied populations, it has been possible to construct instruments that reliably assess the various domains of daily living, thereby producing a meaningful reproducible measurement of quality of life [55–57].

The NYHA angina functional class and cardiac failure functional class reflect symptom-free living with regard to chest pain and dyspnea. Octogenarians have consistently demonstrated substantial improvement in their NYHA angina functional class and cardiac failure functional class after open heart surgery. In several reports, most (68–92%) of the octogenarians who survived open heart surgery were in NYHA functional class I or II during long-term follow-up. This improvement was seen after isolated coronary artery bypass operations, valve operations, and combined operations (Table 52.3). When a well-validated health care index, the SF-36, was employed to study prospectively a cohort of elderly and nonelderly patients, those over 75 years of age enjoyed an identical long-term improvement in each of the seven domains of the SF-36. Indeed, as many of the elderly patients had low quality of life SF-36 scores preoperatively as their younger cohorts, their improvements were even greater, as both populations ended up with statistically identical SF-36 scores 6 months following surgery. Any neurologic injury associated with the diagnostic and surgical process dramatically affected their quality of life adversely when compared with those old patients who did not suffer any neurologic injury.

Many octogenarian patients live alone and consequently have impaired ability to carry out activities of daily living, which places them at a significant disadvantage. Karnofsky dependency category (KDC) and social support index (SSI) reflect the degree of help needed by patients. Glower and coworkers, using the KDC, showed that the median performance status in a group of octogenarians undergoing isolated coronary artery bypass grafting improved from 20% preoperatively to 70% at hospital discharge, with 89% of survivors being discharged home [26]. Kumar et al. showed that when there was a significant decrease in the level of social support needed by octogenarians after open heart surgery, the mean KDC and mean SSI decreased significantly at the short-term follow-up (less than 2 years) [54]. These improvements were also present but significantly less evident at the long-term follow-up (more than 5 years). It is likely that significant comorbid conditions limit the ability of octogenarians to live independently long term, although they remain symptom-free from a cardiac point of view and do well in the short term.

As mentioned above, the subjective indicators of quality of life for octogenarians after open heart surgery are complex and involve a number of modalities relating to various domains of life. In the study by Kumar et al., indices for satisfaction with marriage, children, and overall life, feelings

Table 52.3 Change in functional class after cardiac surgical procedures

				Functional class change (%)	
				Preoperative	Postoperative
Study	Year	No	Procedure	FC III–IV	FC I–II
Deiwick et al. [34]	1997	101	Mixed	88	83
Morris et al. [25]	1996	474	CABG	93	92
Gehlot et al. [38]	1996	322	Mixed	86	82
Sahar et al. [39]	1996	42	Mixed	87	90
Williams et al. [13]	1995	300	CABG	98	98
Logeais et al. [40]	1995	200	Mixed	74	99
Cane et al. [12]	1995	121	Mixed	69	84
Diegeler et al. [29]	1995	54	Mixed	100	92
Adkins et al. [58]	1995	42	Mixed	64	97
Tsai et al. [27]	1994	528	Mixed	99	70
Yashar et al. [42]	1993	43	Mixed	98	79
Tsai et al. [43]	1991	157	CABG	96	73
Ko et al. [28]	1991	100	CABG	100	94
McGrath et al. [30]	1991	54	Mixed	96	94
Mullaney et al. [44]	1990	159	CABG	97	89
Merrill et al. [59]	1990	40	Mixed	100	100
Edmunds et al. [60]	1988	100	Mixed	90	98
Naunheim et al. [24]	1987	23	Mixed	94	83

FC functional class

about the present life, and general affect were assessed. In the short term, the indices for satisfaction with overall life and eight bipolar items assessing general affect showed significant improvements, although all these improvements became less evident at long-term follow-up [54]. Perhaps the symptomatic benefits and the value of cardiac surgery as seen subjectively by the patients lie in the question, “Would you choose to undergo cardiac surgery again?” Virtually all the current studies in the literature have shown that most octogenarians would have made the same decision to undergo open heart surgery retrospectively.

Possible Strategies to Decrease Operative Risk

Improvements in surgical techniques and anesthesia have increased the confidence of cardiac surgeons performing operations on an elderly population with increased perioperative risk. Awareness of the problems unique to this growing population of elderly patients, along with recent statistical data highlighting the impact of these problems on morbidity and mortality, can help the medical team recommend the most appropriate treatment choice and timing of intervention in each individual case.

The two principal causes of perioperative cerebrovascular accidents (CVAs) in elderly patients undergoing cardiac surgery are embolization (air, atheroma, and calcific debris) and hypotension resulting in inadequate perfusion of the central nervous system. Preoperative evaluation of the ascending aorta and carotid arteries and intraoperative assessment of the proximal aorta using transesophageal or epiaortic echocardiography may alter the conduct of the procedure, minimize intraoperative manipulation, and thereby significantly reduce the incidence of stroke [34, 35, 39, 51, 61]. Such information enables the surgeon to avoid cannulation or direct manipulation of heavily diseased portions of the aorta where atheromas may dislodge or where plaque disruption may cause aortic dissection. The presence of extensive atheromatous or calcific disease, which precludes safe manipulation of the ascending aorta in patients with advanced coronary disease, leaves the surgeon with several choices.

1. Abandon the surgical procedure and consider nonoperative or nonbypass revascularization, such as angioplasty, transmyocardial revascularization, or angiogenesis.
2. Perform surgical revascularization on a beating heart, using one or both internal thoracic arteries or nonaortic-based grafts.
3. Establish cardiopulmonary bypass via the femoral, axillary, or other systemic nondiseased artery and perform graft replacement or endarterectomy of the ascending aorta [34, 35]. The latter alternative is an aggressive, complex procedure and in the elderly population it should be reserved for the very good risk patient with no significant comorbidities.

Diffuse systemic atherosclerosis is more prevalent in the elderly than in younger patients; as such, special precautions should be taken to ensure adequate cerebral and renal perfusion perioperatively. Maintaining high perfusion pressures while on cardiopulmonary bypass can help decrease the incidence of ischemic stroke [62, 63]. Control of atrial arrhythmias and avoidance of episodes of sustained arterial hypotension due to hypovolemia or medications are important during the immediate postoperative period. Although there is still controversy regarding the management of asymptomatic carotid disease, it is believed that known carotid disease in the elderly population is a risk factor for postoperative CVA [14, 34, 44, 51]. Morris et al. [25] recommended routine preoperative assessment of carotid artery disease in octogenarians and advocated carotid endarterectomy if significant disease is found. If symptomatic carotid artery disease is diagnosed prior to cardiac surgical intervention, consideration should be given to performing a staged or a combined procedure. If asymptomatic significant carotid disease is discovered by Doppler preoperatively (>75% stenosis bilaterally or lesser degrees of unilateral stenosis in the presence of an occluded contralateral artery), concomitant carotid endarterectomy may decrease the risk of perioperative stroke [61].

Because of the significant increase in mortality associated with urgent or emergent operative procedures (Table 52.2), all possible measures must be taken to optimize the elderly patient preoperatively and possibly convert an urgent or emergent situation to a more elective one. Careful selection of elderly patients in this setting is critical, and one must evaluate the patient’s mental status and existing comorbidities when determining the potential for meaningful survival before recommending operation. Aggressive preoperative medical management includes the use, when necessary, of intravenous nitroglycerin or heparin (or both), inotropic and ventilatory support, and if absolutely necessary, the IABP. Although numerous studies have reported that preoperative use of the IABP is a significant predictor of perioperative mortality [12, 14, 33, 50], it likely reflects the severity of the elderly patient’s underlying cardiac disease, rather than any inherent risk in using the device. Sisto et al. [64] reported that in 25 consecutive octogenarians requiring IABP insertion, there were no significant complications related to device insertion; and of 20 patients who eventually underwent surgery after IABP, only two patients (10%) died in hospital. This operative mortality rate is significantly better than that reported by others for urgent/emergent cases (Table 52.2).

There is a strong association between early postoperative death and prolonged ventilatory dependence [60], which can develop quickly in the elderly patient. As soon as the patient awakens from general anesthesia, respiratory muscles must be exercised. Pulmonary hygiene and physiotherapy must be aggressive with early and progressive ambulation. Unlike their younger counterparts, elderly patients have much less functional reserve, and therefore a successful first attempt at extubation and mobilization ensures the best outcome. Intraoperatively, exquisite care must be taken to avoid injury to the phrenic nerve during harvesting of the internal thoracic artery, and use of bilateral internal thoracic arteries should generally be avoided [65].

Nephrotoxic drugs should be avoided; or, if necessary, doses should be adjusted in light of the decreased renal function in elderly patients. Intravenous renal dosage dopamine hydrochloride (1–2 μg/kg/min) may have benefit when used for any patient with preexisting renal insufficiency. Because of the high mortality associated with perioperative renal failure in this population [13, 38, 43, 66, 67], an aggressive approach to optimize preoperative renal function is essential. Although rigorous studies demonstrating the benefit of "renal dopamine" are inconclusive, many centers use this drug to enhance urine flow during and immediately after cardiac surgery.

Cognitive function is one of the most important factors affecting overall outcome and is one of the most difficult neurologic outcome parameters to measure and assess. Delirium and confusion are common in the postoperative elderly individual and can hinder important initial attempts to extubate and mobilize a patient. Encephalopathy changes are seen in as many as 30% of all bypass patients and 50% of elderly patients. Sensory deficits such as those due to hearing or vision impairments can be addressed as soon as the patient awakens by providing hearing aids and eyeglasses. Invasive lines and monitoring equipment should be removed as soon as the patient is medically possible to facilitate mobilization. Transfer out of an intensive care unit (ICU) setting, when possible, helps restore the sleep–wake cycle. Family members should stay with confused patients to offer reassurance and encouragement. Long-acting benzodiazepines should be avoided or other sedative/hypnotic medications altered to prevent excessive sedation, confusion, and respiratory depression. Haloperidol is a more appropriate drug for the management of delirium in this patient population because of its short-acting effect and safety margin in the postoperative cardiothoracic patient. Small doses are usually effective, and the patient can be rapidly weaned in conjunction with professional and family encouragement.

Octogenarians are more likely to develop sternal dehiscence due to osteoporosis of the sternum. The use of bilateral internal thoracic arteries should be avoided. Sternal wound infection has been shown to be a positive predictor of mortality in this group of patients [13].

Aggressive management is essential and includes early institution of intravenous antibiotics, timely debridement, and either primary reconstruction or secondary closure with a wound vacuum device. Adequate nutrition and pulmonary physiotherapy are critical to success. Staged closures are to be avoided in this population, other than for the most advanced infections, which should then undergo coverage and secondary closure as rapidly as possible.

Utley and Leyland described a highly selected group of 25 patients over the age of 80 who underwent coronary artery bypass with no hospital deaths [68]. Patients were selected on the basis of their ability to achieve acceptable functional recovery after operation. All patients were living at home alone or with relatives preoperatively, and they were ambulatory and capable of caring for their own personal needs. They were counseled preoperatively regarding the importance of early ambulation and self-care postoperatively. Four patients were rejected for surgery based on mental or physical senility, previous debilitating strokes, or a history of long-term institutional care. Anesthetic management included the use of short-acting agents and minimal use of postoperative sedation. Patients were extubated within 9–48 h postoperatively, and many were ambulatory and eating on the first postoperative day. Although this restrictive degree of patient selection is not appropriate in most cases, it illustrates how outcome can be strongly influenced by preexisting functional status and meticulous perioperative care.

Nonsurgical Alternatives

During the current era of health care reform, there is considerable interest in providing the most appropriate care for patients more than 80 years of age at an "acceptable" cost [69]. As coronary bypass surgery is the most common major operation performed in the USA (more than 300,000 done annually), the use of coronary bypass in the very elderly is an important issue in the present cost-conscious environment. Medicare data from 1987 to 1990 indicated that the use of this operation in patients more than 80 years of age increased by 67% during that time period [49]. The projected rise in the number of coronary bypass procedures to be done in these patients and associated costs is impressive (Fig. 52.2) [49]. Numerous studies have shown a considerable increase in length of stay (3–4 days longer) and hospital costs ($3,000–$6,000 more) in patients over 80 years old versus their younger counterparts. Failure to provide this service, however, often results in repeated and prolonged hospitalization, the need for multidrug therapy, and poorer quality of life, not to mention the emotional impact on patients and their families [7, 49].

In one series of octogenarians, when coronary surgery was compared with medical therapy, the overall cost, annual reinterventions, coronary disease-associated readmissions, and mortality were favored in the surgical group. Several studies have attempted to compare the treatment results of less expensive alternatives to coronary bypass surgery. In elderly patients, percutaneous transluminal coronary angioplasty (PTCA) has the advantages of shorter hospital stay, less immobilization, and lower cost compared with coronary artery bypass; however, coronary bypass confers greater and more durable freedom from angina, less need for future repeat interventional measures, and overall improved quality of life [36, 70, 71]. Although Mick et al. [72] reported that the procedural complication rates in matched groups of patients undergoing coronary bypass versus PTCA were similar, Braunstein et al. [70] observed that PTCA in the setting of unstable angina was associated with high initial morbidity but long-term survival roughly equivalent to that after coronary bypass surgery. As mentioned above, compared with medical noninterventional therapy, coronary artery bypass provides a significant survival advantage and improved quality of life. Ko et al. [71] compared 36 octogenarians who underwent coronary artery bypass with 29 octogenarians who continued medical noninterventional therapy and found that the functional class did not change in the latter group but improved significantly in the former group (NYHA functional class decreased from 3.4 to 1.2, $p<0.01$). The 3-year survival rate of 77% for the surgical group was similar to the survival of octogenarians in the general US population and was significantly better than that of 55% for the medical group. In summary, coronary bypass surgery provided improved long-term survival and functional benefit compared with medical therapy and improved the quality of life compared with PTCA.

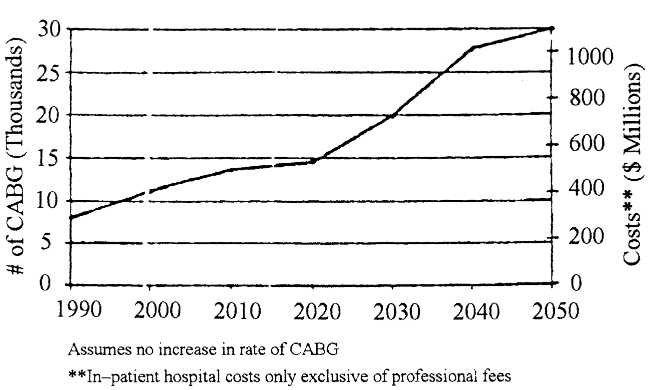

Figure 52.2 Projected number of bypass surgery (CABG) procedures performed per year in octogenarians (*left axis*) and the corresponding projected costs for these procedures (in 1990 dollars) (*right axis*) (from Peterson et al. [49], with permission).

The New Era of Mechanical Circulatory Assist

In the mid-1980s, implantable mechanical circulatory assist devices were introduced in FDA clinical trials for patients with severe left ventricular dysfunction who were awaiting transplant and would otherwise not survive without such support. The most popular device in this early era, the HeartMate pneumatic left ventricular assist device (LVAD), enabled patients to ambulate and exercise on treadmills while in-hospital. The advantages of LVAD therapy for the often debilitated, deconditioned patients were significant and resulted in improved outcomes for heart transplant recipients who were able to optimize their physical and physiologic conditions prior to transplant. Since then the LVADs have become smaller (Figs. 52.3 and 52.4), more durable, and associated with increased survival rates when compared with the earlier models [73]. The smaller size and decreased postoperative complications have enabled this technology to be offered to the elderly population with acceptable perioperative risk.

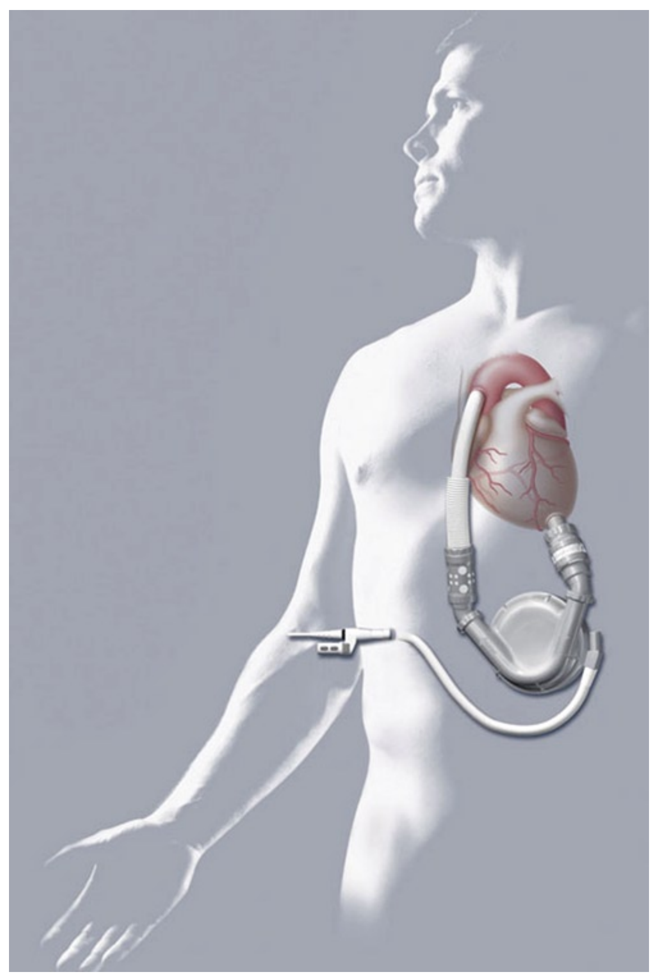

Figure 52.3 HeartMate II LVAD (reprinted with permission of Thoratec Corporation).

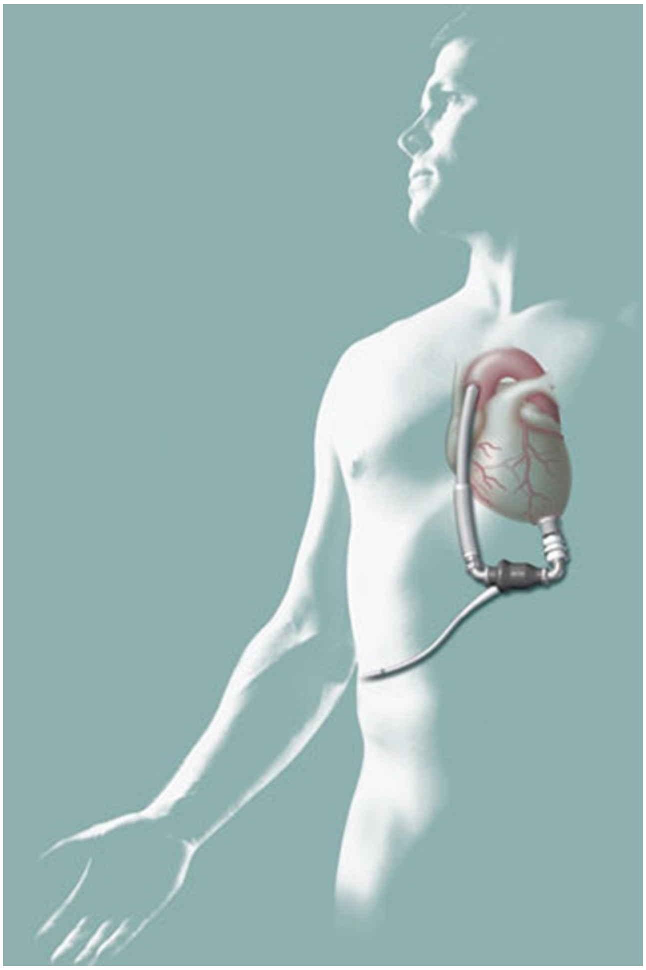

Figure 52.4 Mechanical circulatory support device placement (reprinted with permission of Thoratec Corporation).

The oldest patients with these smaller LVADs are octogenarians who, like their younger counterparts, are leading productive lives outside the hospital.

For a selective group of elderly but active patients who suffer hemodynamic compromise due to severe cardiac dysfunction, a temporary mechanical assist device can be implanted if there is hope of cardiac recovery, such as after a large myocardial infarction. Newer devices in this category, such as the Thoratec CentriMag, have been associated with fewer complications and improved survival (personal communication).

Guidelines for Therapy in the Elderly Cardiac Surgery Patient

During the process of deciding whether to offer cardiac surgical intervention to elderly patients, the relief of symptoms and improvement in quality of life should assume more importance than the issue of increased life expectancy. When surgical revascularization is considered in this patient population, numerous social, ethical, and clinical issues arise. Comorbidities, quality of life, and concerns raised by the patient's family should be acknowledged and factored into the decision-making process. It is important to integrate the patient's and family's wishes, but one must focus the therapeutic decisions on the patient's advance directives. Emergency cases in these patients may be associated with more than 70% mortality risk, and therefore nonoperative treatment must be strongly considered. Asymptomatic patients should continue medical treatment unless there is critical (>70%) left main coronary artery stenosis, which is associated with significantly reduced life expectancy. Numerous groups (Table 52.2) have observed significantly increased mortality when combined procedures were performed. One study, comparing the operative mortalities for isolated AVR and isolated coronary artery bypass to combined AVR + coronary bypass, demonstrated five- to sixfold increased operative mortality in the combined procedure group [48]. In situations where two or three disease processes exist, the surgical plan should be modified to avoid such increased risks. For example, in an elderly patient with angina, severe coronary artery disease, and noncritical aortic stenosis, coronary revascularization alone may be the best option. Such patients are usually not at risk for a serious morbid event due to their aortic stenosis [36]. Conversely, in a patient with critical aortic stenosis, congestive heart failure, preserved or mildly impaired left ventricular function, and noncritical coronary lesions (<70–80% stenosis), valve replacement alone may be the best alternative. Fiore et al. [46] noted that of the early deaths of patients undergoing combined AVR + coronary bypass, 60% were due to low cardiac output; the patients who had died had little or no angina preoperatively, but each had considerable congestive heart failure and may have been better served by valve replacement alone.

Definitive treatment of isolated aortic stenosis is surgical replacement of the valve, preferably with a bioprosthesis that prevents a lifelong requirement for anticoagulation. The tissue valves have demonstrated impressive freedom from structural deterioration and reoperation at 10 or even 15 years in patients older than 65 years of age. Stentless bioprostheses may have some advantage in elderly small aortic root patients, but long-term benefit and durability remain unproven. Percutaneous balloon valvuloplasty may offer effective initial palliation, but medium- and long-term durability results have been disappointing. Symptoms recurred within 1 year in most patients and necessitated subsequent surgery [74, 75].

Chronic aortic regurgitation may be well tolerated for several decades before congestive heart failure occurs. Once symptoms appear and ventricular dilatation begins, AVR

CASE STUDY: CROSSING THE FRONTIER

Stanley M., an active male in his late 1970s, presented to a local hospital near his home in New Jersey after suffering a large myocardial infarction. Due to hemodynamic instability, he received an IABP, was intubated and transferred to Newark Beth Israel Medical Center for further treatment. Despite high-dose inotropes, he was not able to be weaned from the IABP and remained intubated. He received an implantable LVAD, the newer and smaller HeartMate II, as part of a clinical trial. He was able to be extubated and weaned from the IABP, and was discharged home to lead an active life that includes travel and caring for his brother. Had this technology not been available to Stanley, he would have expired in the hospital [77].

should be offered before chronic volume overload results in symptomatic irreversible myocardial and pulmonary damage. The most appropriate time to replace the valve is soon after left ventricular dilatation begins.

Surgery is usually recommended for mitral stenosis patients with NYHA functional class II–III heart failure and a calculated mitral valve area less than 1.0 cm^2. Percutaneous balloon mitral valvuloplasty, unlike the similar treatment for stenotic aortic valves, may be useful when only the mitral valve leaflets are impaired and there is no significant calcification or regurgitation. The subvalvular apparatus should be functional and not destroyed, as can happen with advanced rheumatic valve disease [76]. Mitral valve balloon valvuloplasty usually provides relatively long-term relief of dyspnea but is frequently not possible in elderly patients with advanced disease and heavily calcified mitral valves. MVR, although the definitive treatment for mitral valve stenosis, carries significantly increased procedural mortality either alone or combined with other procedures in the elderly. Naunheim et al. [33] observed operative risks of 42% for either MVR alone or MVR + coronary bypass. Combined MVR + AVR was associated with a 67% risk of surgical mortality, further suggesting a limited role for MVR in this elderly population. These procedures require prolonged periods of cardiopulmonary bypass and global cardiac ischemia, both of which are poorly tolerated by such patients with limited cardiac and other organ reserve. For these reasons, Fiore et al. [46] recommended that every effort be made to keep such operations simple and expeditious.

In patients with advanced coronary artery disease who may be at high risk for complications arising from cardiopulmonary bypass, such as those with severe calcific disease of the ascending aorta (precluding safe insertion of cannulas), a history of stroke, or end-stage pulmonary or renal failure, an alternate option is surgical revascularization on a beating heart. Technologic advances in pericardial retraction systems and stabilization devices have enabled the surgeon to perform anastomoses on a beating heart with the use of newer surgical techniques. However, there is a significant learning curve, as the surgical field is not nearly as optimal as that produced by cardiopulmonary bypass and ischemic arrest. Recent reports have observed a failure rate of 10% even in experienced hands. Although a reasonable alternative for patients who would otherwise have no interventional options, the increased risk of technical failure must be kept in mind and discussed with the patient and family.

Finally, for elderly patients in previously good physical and mental condition who suffer from acute or chronic severe ventricular dysfunction, both short-term and long-term mechanical circulatory assist devices are available at an acceptable operative risk, compared with their earlier counterparts.

Conclusions

As the elderly population has grown, so have the number of elderly patients being referred for cardiac surgery and their disease complexity. For the most part, these patients can be offered conventional surgical procedures with acceptable mortality, morbidity, and long-term quality of life expectations. Indeed, the perioperative complications are somewhat more numerous than for younger patients even when they are compared for procedure and matched for other risk factors.

This incremental morbidity and mortality is seen across the entire population but is most pronounced in emergently operated patients. With the availability of new and different techniques to accomplish myocardial revascularization and valvular repair and replacement, and the recent availability of mechanical assist devices, the range of procedures available for elderly patients with hemodynamically important heart disease is increasing at a rate almost faster than the population itself has grown. It is therefore critical that the health care professionals caring for these older patients are aware of ongoing developments in these areas and carefully stratify the preoperative risk factors to best select the least morbid and most effective procedure that is currently available.

Acknowledgments The authors wish to acknowledge the invaluable assistance of Melissa L. Wong and Gladys Madrid RN for the creation of this manuscript.

References

1. Table 1: Annual Estimates of the Resident Population by Sex and Five-year Age Groups for the United States: April 1, 2000 to July 1, 2008 (NC-EST2008-01). Source: Population Division, US Census Bureau; Release Date May 14, 2009 and Table 4: Annual Estimates of the Resident Population for the United States April 1, 2000 to July 1, 2008 (NST-EST 2008-01). Source: Population Division, US Census BUREAU; Release date December 22, 2008
2. Lubitz J, Kiming C, Kramarow E et al (2003) Health, life expectancy and health care spending among the elderly. N Engl J Med 349:1048–1055
3. Horvath KA, DiSesa VJ, Peigh PS et al (1990) Favorable results of coronary artery bypass grafting in patients older than 75 years. J Thorac Cardiovasc Surg 99:92–96
4. Maganti M, Rao V, Brister S et al (2009) Decreasing mortality for coronary artery bypass surgery in octogenarians. Can J Cardiol 25(2):e32–e35
5. Canver C, Nichols R, Cooler S et al (1996) Influence of increasing age on long-term survival after coronary artery bypass grafting. Ann Thorac Surg 62:1123–1127
6. Srinivasan A, Oo A, Grayson A et al (2004) Mid-term survival after cardiac surgery in elderly patients: analysis of predictors for increased mortality. Interact Cardiovasc Thorac Surg 3:289–293
7. Alexander KP, Peterson ED (1997) Coronary artery bypass grafting in the elderly. Am Heart J 134:856–864
8. Kern LS (1991) The elderly heart surgery patient. Crit Care Nurs Clin North Am 3:749–756
9. Mezey MD, Rauckhorst LH, Stokes SA (1993) Health assessment of the older individual, 2nd edn. Springer, New York
10. Smith Rossi M (1995) The octogenarian cardiac surgery patient. J Cardiovasc Nurs 9(4):75–95
11. Sweet J, Finnin E, Wolfe P et al (2008) Absence of cognitive decline one year after coronary bypass surgery: comparison to non-surgical and healthy controls. Ann Thorac Surg 85:1571–1578
12. Cane ME, Chen C, Bailey BM et al (1995) CABG in octogenarians: early and late events and actuarial survival in comparison with a matched population. Ann Thorac Surg 60:1033–1037
13. Williams DB, Carrillo RG, Traad EA et al (1995) Determinants of operative mortality in octogenarians undergoing coronary bypass. Ann Thorac Surg 60:1038–1043
14. Akins CW, Daggett WM, Vlahakes GJ et al (1997) Cardiac operations in patients 80 years old and older. Ann Thorac Surg 64:606–615
15. Iskandrian AS, Segal BL (1991) Should cardiac surgery be performed in octogenarians? J Am Coll Cardiol 18:36–37
16. Shirani J, Yousefi J, Roberts WC (1995) Major cardiac findings at necropsy in 366 American octogenarians. Am J Cardiol 75:151–156
17. Iskandrian AS, Hakki AH (1985) The effects of aging after coronary artery bypass grafting on the regulation of cardiac output during upright exercise. Int J Cardiol 7:347–360
18. Hakki AH, DePace NL, Iskandrian AS (1983) Effect of age on left ventricular function during exercise in patients with coronary artery disease. J Am Coll Cardiol 2(4):645–651
19. Iskandrian AS, Hakki AH (1986) Age-related changes in left ventricular diastolic performance. Am Heart J 112:75–78
20. Roberts WC (1993) Ninety three hearts ≥90 years of age. Am J Cardiol 71:599–602
21. Waller BF, Roberts WC (1983) Cardiovascular disease in the very elderly: analysis of 40 necropsy patients aged 90 years or older. Am J Cardiol 51:403–421
22. Roberts WC (1988) The aging heart. Mayo Clin Proc 63:205–206
23. Gersh BJ, Kronmal RA, Schaff HV et al (1983) Long-term (5 year) results of coronary bypass surgery in patients 65 years or older: a report from the Coronary Artery Surgery Study. Circulation 66(Suppl II):190–199
24. Naunheim KS, Kern MJ, McBride LR et al (1987) Coronary artery bypass surgery in patients aged 80 years or older. Am J Cardiol 59:804–807
25. Morris RJ, Strong MD, Grunewald KE et al (1996) Internal thoracic artery for coronary artery grafting in octogenarians. Ann Thorac Surg 62:16–22
26. Glower DD, Christopher TD, Milano CA et al (1992) Performance status and outcome after coronary artery bypass grafting in persons aged 80 to 93 years. Am J Cardiol 70:567–571
27. Tsai T, Chaux A, Matloff JM et al (1994) Ten-year experience of cardiac surgery in patients aged 80 years and over. Ann Thorac Surg 58:445–451
28. Ko W, Krieger KH, Lazenby WD et al (1991) Isolated coronary artery bypass grafting in one hundred consecutive octogenarian patients. J Thorac Cardiovasc Surg 102:532–538
29. Diegeler A, Autschbach R, Falk V et al (1995) Open heart surgery in the octogenarians: a study on long-term survival and quality of life. Thorac Cardiovasc Surg 43:265–270
30. McGrath LB, Adkins MS, Chen C et al (1991) Actuarial survival and other events following valve surgery in octogenarians: comparison with age-, sex-, and race-matched population. Eur J Cardiothorac Surg 5:319–325
31. Freeman WK, Schaff HV, O'Brien PC et al (1991) Cardiac surgery in the octogenarian: perioperative outcome and clinical follow-up. J Am Coll Cardiol 18:29–35
32. Bashour TT, Hanna ES, Myler RK et al (1990) Cardiac surgery in patients over the age of 80 years. Clin Cardiol 13:267–270
33. Naunheim KS, Dean PA, Fiore AC et al (1990) Cardiac surgery in the octogenarian. Eur J Cardiothorac Surg 4:130–135
34. Deiwick M, Tandler R, Mollhoff TH et al (1997) Heart surgery in patients aged eight years and above: determinants of morbidity and mortality. Thorac Cardiovasc Surg 45:119–126
35. Wareing TH, Davila-Roman VG, Barzilai B et al (1992) Management of the severely atherosclerotic ascending aorta during cardiac operations: a strategy for detection and treatment. J Thorac Cardiovasc Surg 103:453–462
36. Cannon LA, Marshall JM (1993) Cardiac disease in the elderly population. Clin Geriatr Med 9:499–525
37. Davis EA, Gardner TJ, Gillinov AM et al (1993) Valvular disease in the elderly: influence on surgical results. Ann Thorac Surg 55:333–338
38. Gehlot A, Mullany CJ, Ilstrup D et al (1996) Aortic valve replacement in patients aged eighty years and older: early and long-term results. J Thorac Cardiovasc Surg 111:1026–1036
39. Sahar G, Raanani E, Sagie A et al (1996) Surgical results in cardiac patients over the age of 80 years. Isr J Med Sci 32:1322–1325
40. Logeais Y, Roussin R, Langanay T et al (1995) Aortic valve replacement for aortic stenosis in 200 consecutive octogenarians. J Heart Valve Dis 4(Suppl 1):S64–S71
41. Klima U, Wimmer-Greinecker G, Mair R et al (1994) The octogenarians: a new challenge in cardiac surgery? Thorac Cardiovasc Surg 42:212–217
42. Yashar JJ, Yashar AG, Torres D, Hittner K (1993) Favorable results of coronary artery bypass and/or valve replacement in octogenarians. Cardiovasc Surg 1:68–71
43. Tsai T, Nessim S, Kass RM et al (1991) Morbidity and mortality after coronary artery bypass in octogenarians. Ann Thorac Surg 51:983–986

44. Mullany CJ, Darling GE, Pluth JR et al (1990) Early and late results after isolated coronary artery bypass surgery in 159 patients aged 80 years and older. Circulation 82(Suppl IV):229–236
45. Kowalchuk GJ, Siu SC, McAuliffe LS et al (1990) Coronary artery bypass in octogenarians: early and late results. J Am Coll Cardiol 15:35A
46. Fiore AC, Naunheim KS, Barner HB et al (1989) Valve replacement in the octogenarian. Ann Thorac Surg 48:104–108
47. Rich MW, Sandza JG, Kleiger RE et al (1985) Cardiac operations in patients over 80 years of age. J Thorac Cardiovasc Surg 90:56–60
48. Tsai TP, Matloff JM, Gray RJ et al (1986) Cardiac surgery in the octogenarian. J Thorac Cardiovasc Surg 91:924–928
49. Peterson ED, Cowper PA, Jollis JG et al (1995) Outcomes of coronary artery bypass graft surgery in 24,461 patients aged 80 years or older. Circulation 92(Suppl II):85–91
50. Curtis JJ, Walls JT, Boley TM et al (1994) Coronary revascularization in the elderly: determinants of operative mortality. Ann Thorac Surg 58:1069–1072
51. Tuman KJ, McCarthy RJ, Najafi H et al (1992) Differential effects of advanced age on neurologic and cardiac risks of coronary artery operations. J Thorac Cardiovasc Surg 104:1510–1517
52. Lee EM, Porter JN, Shapiro LM et al (1997) Mitral valve surgery in the elderly. Heart Valve Dis 6:22–31
53. Culliford AT, Galloway AC, Colvin SB et al (1991) Aortic valve replacement for aortic stenosis in persons aged 80 years and over. Am J Cardiol 67:1256–1260
54. Kumar P, Zehr KJ, Cameron DE et al (1995) Quality of life in octogenarians after open heart surgery. Chest 108:919–926
55. Remington M, Tyrer PJ, Newson-Smith J et al (1979) Comparative reliability of categorical and analogue rating scales in the assessment of psychiatric symptomatology. Psychol Med 9:765–770
56. Campbell A, Converse PE, Ridgers WL (1976) The quality of American life. Russell Sage, New York, pp 1–583
57. Bradburn NM (1969) The structure of psychological well-being. Aldine, Chicago, pp 214–215
58. Adkins M, Amalfitano D, Harnum NA et al (1995) Efficacy of combined coronary revascularization and valve procedures in octogenarians. Chest 108:927–931
59. Merrill WH, Steward JR, Frist WH et al (1990) Cardiac surgery in patients age 80 years or older. Ann Surg 211:772–776
60. Edmunds LH, Stephenson LW, Edie RN et al (1988) Open-heart surgery in octogenarians. N Engl J Med 319:131–136
61. Berens ES, Kouchoukos NT, Murphy SF et al (1992) Preoperative carotid artery screening in elderly patients undergoing cardiac surgery. J Vasc Surg 15:313–323
62. Grawlee GP, Cordell AR, Graham JE et al (1985) Coronary revascularization in patients with bilateral internal carotid occlusion. J Thorac Cardiovasc Surg 90:921–925
63. Brener BJ, Bried DK, Alpert J et al (1987) The risk of stroke in patients with asymptomatic carotid stenosis undergoing cardiac surgery: a follow-up study. J Vasc Surg 5:269–279
64. Sisto DA, Hoffman DM, Fernandes S, Frater RWM (1992) Is use of the intraaortic balloon pump in octogenarians justified? Ann Thorac Surg 54:507–511
65. He GW, Acuff TE, Ryan WH et al (1994) Determinants of operative mortality in elderly patients undergoing coronary artery bypass grafting. J Thorac Cardiovasc Surg 108:73–81
66. Ennabli K, Pelletier LC (1986) Morbidity and mortality of coronary artery surgery after the age of 70 years. Ann Thorac Surg 42:197–200
67. Higgins TL, Estafanous FG, Loop FD et al (1992) Stratification of morbidity and mortality outcome by pre-operative risk factors in coronary artery bypass patients: a clinical severity score. JAMA 267:2344–2348
68. Utley JR, Leyland SA (1991) Coronary artery bypass grafting in the octogenarian. J Thorac Cardiovasc Surg 101:866–870
69. Weintraub WS (1995) Coronary operations in octogenarians: can we select the patients? Ann Thorac Surg 60:875–876
70. Braunstein EM, Bajwa TK, Andrei L et al (1991) Early and late outcome of revascularization for unstable angina in octogenarians. J Am Coll Cardiol 17:151A
71. Ko W, Gold JP, Lazzaro R et al (1992) Survival analysis of octogenarian patients with coronary artery disease managed by elective coronary artery bypass surgery versus conventional medical treatment. Circulation 86(Suppl II):191–197
72. Mick MJ, Simpfendorfer C, Arnold AZ et al (1991) Early and late results of coronary angioplasty and bypass in octogenarians. Am J Cardiol 68:1316–1320
73. Camacho M, Baran D, Martin A et al (2009) Improved survival in high-risk patients with smaller implantable LVAD's: single-center experience over 3 years. J Heart Lung Transplant 28(2):S274
74. Dancy M (1989) Dawkins, Ward D. Balloon dilatation of the aortic valve; limited success and early restenosis. Br Heart J 60:236–239
75. Litvack F, Jakubowski AT, Buchbinder NA et al (1988) Lack of sustained clinical improvement in an elderly population after percutaneous aortic valvuloplasty. Am J Cardiol 62:270–275
76. Palacios I, Block PC, Brandi S et al (1987) Percutaneous balloon valvotomy for patients with severe mitral stenosis. Circulation 75:778–786
77. Health Care Today: post-acute care. Producer: Paula Levine. January 2008