Chapter

Early and Late Survival and Associated Factors in Patients Undergoing Coronary Artery Bypass Grafting

Ahmad Amouzeshi and Zahra Amouzeshi

Abstract

Several studies have aimed to compare the early and late survival rates and the related factors in patients who undergo coronary artery bypass grafting (CABG). Among such factors are age, gender, arrhythmia, stroke, serum procalcitonin level, number and type of grafts, diabetes mellitus, chronic kidney disease, chronic obstructive pulmonary disease (COPD), addiction, ejection fraction, transfusion of blood products, and the kind of technique (off-pump versus on-pump). Controversies surround early and late survival and some of the associated factors in patients undergoing CABG. Therefore, it appears vital to compare the early and late survival chances and the related factors after CABG.

Keywords: coronary artery bypass grafting, survival, patients, cardiac surgery

1. Introduction

CABG continues to be the most common procedure in adult cardiac surgery for coronary artery disease [1]. CABG improves survival, particularly in complex diabetic patients, those above 65 years of age, patients with left main stem or triple-vessel disease, and those who have an impairment in the left ventricular function [2].

Many studies have attempted to compare the early and late survival rates and the relevant factors in patients who undergo CABG. A 20-year follow-up investigation of patients undergoing CABG reported lower survival rates as related to the female gender, age, hypertension, previous CABG, angina class, number of vessels diseased, heavyweight, and ejection fraction (EF) [3]. Another study shows that late survival is associated with increased weight, history of myocardial infarction, smoking, diabetes, and application of vein grafts merely in CABG patients [4].

In light of the current controversy over early and late survival rates and some of the related factors in patients undergoing CABG, it seems critically important to compare the early and late survival chances and associated factors after CABG.

1.1 Gender

Most studies report that women hold a higher risk for morbidity and mortality after CABG procedures than their male counterparts do [5, 6]. Abramov's study

demonstrated that there is a greater prevalence of most risk factors in women (including old age, urgent operation, prior PTCA, Canadian Cardiovascular Society angina class 3–4, congestive heart failure, hypertension, diabetes mellitus, peripheral vascular disease, and smaller body surface area). Men have a higher prevalence of left ventricular EF of <35%, triple-vessel disease, and history of smoking. Moreover, Abramov's study found that internal mammary artery grafts and multiple arterial grafts were not used as frequently in women as in men [5]. It should be highlighted that a critical difference between men and women is the later onset of coronary artery disease in women. By inference, after age is controlled, female patients undergoing surgery may have a shorter duration of coronary artery disease, which would be associated with longer life [5].

1.2 Age

Demographic changes over the last decades have resulted in a different patient population for surgeons, including cardiac surgeons. It is now typical of elderly patients to have several, relatively severe comorbidities such as hypertension, pulmonary diseases, diabetes, obesity, renal insufficiency, as well as peripheral arterial disease (PAD) [7].

Alongside this, Naughton compared the early and late predictors of mortality after on-pump CABG in an elderly and a younger population, showing that mortality in elderly patients improved substantially, although it remained more than twice that of younger patients. The difference in contributors to early and 1-year mortality implies the need for effectual short- and long-term strategies, especially in controlling chronic diseases such as heart and renal failure [8].

Coronary artery revascularization via CABG surgery or percutaneous coronary intervention in 80-year-old patients or older can have satisfactory in-hospital and 2-year clinical outcomes. Nevertheless, recovery may be prolonged in up to 20% of patients, and they may not be immediately able to leave the hospital [9].

In Nicolini's study [10], patients younger than 60 years undergoing CABG showed a lower risk of undesirable outcomes than older patients. Patients younger than 60 have a different clinical pattern of coronary artery disease (CAD) presentation as compared to more elderly patients. Especially speaking, the factors of obesity, male gender, the history of myocardial infarction, the history of PCI, and the presence of depressed left ventricular function, have been found to be highly commonplace among patients younger than 60. Focused attention should be directed to these issues if one aims to design and improve preventive strategies than can alleviate the effect of specific cardiovascular risk factors for younger patients, including lifestyle, diet, and weight control. More research with longer follow-up periods should be performed to investigate the efficacy and durability of myocardial revascularization in younger patients in need of CABG [10].

1.3 Biomarkers

According to Petäjä's meta-analysis, postoperative CK-MB release is linked with survival up to 40 months after surgery. Troponin levels can assumedly be better predictors of mortality than CK-MB due to their specificity to the myocardium [11].

Also, high levels of postoperative serum procalcitonin have been demonstrated to correlate with infection, mortality, and other severe post-cardiac surgery complications [12]. Dörge et al. revealed that survival rates in the first 24 h after the operation are lower in patients with high levels of serum PCT [13]. Fritz et al. [14] also reported that a PCT level greater than 2.5 ng l^{-1} could be predictive of mortality within the first 28 days after CABG surgery [14].

1.4 Type of grafts

Completeness of revascularization is contingent upon the number of grafts required, the type of graft, and the number of grafts performed [15]. Saphenous vein grafts (SVG) are the most frequently employed conduits from among arterial and venous conduits for CABG surgery. It is because they are characterized by superficial access site and reduced risk for bleeding compared with arterial conduits. Endoscopic SVG harvest was reported to have short-term graft patency similar to open SVG harvest, although there are concerns for a significantly reduced long-term graft patency at 12 months and beyond. Given the potential implications of endoscopic SVG harvest for deteriorated long-term outcomes in patients undergoing CABG, its role has received much controversy in the literature, although it is generally considered non-subsidiary to open harvest [1].

Amouzeshi's study showed that EVH is a safe and minimally invasive technique for vein harvesting and that it can decrease the harvest time and postoperative pain. Moreover, the efficiency of EVH and OVH is similar. Nevertheless, further research is needed to probe into its cosmetic outcomes, cost-efficiency, and hospital costs; it is even more essential to study the long-term graft patency of the EVH technique [16].

The systematic review and meta-analysis conducted by Kodia on 18,131 patients undergoing CABG showed greater patency via open SVG harvest than endoscopic SVG harvest after a follow-up of around 2.5 years. Patients with open SVG harvest showed higher rates of early wound complications and postoperative 30-day mortality, which, importantly, did not mean differences in overall mortality [1].

Finally, Grau's study indicated that bilateral internal mammary artery had better outcomes than single internal mammary artery [17].

A meta-analysis incorporating 27 studies and over 79,000 patients revealed a higher survival rate among patients who received bilateral internal mammary artery (BIMA) as compared with those who underwent left internal mammary artery for CABG surgery. While it is imperative to tailor the surgery to each patient, no one can disregard the advantage and gain from this operative strategy. Moreover, given the reduced rates of short-term morbidity (i.e., deep sternal wound infection) through better operative techniques, BIMA bypass grafting can be a first-line alternative for patients receiving revascularization [18].

1.5 Stroke

Stroke is a primary cause of morbidity and mortality following CABG. It continues to be one of the most disabling and damaging complications of CABG, which carries significant clinical and economic implications for both patients and the healthcare system [19, 20]. Moreover, it is a potentially preventable complication of CABG [20].

The results from Tarakji's study on patients undergoing CABG at a single center during a 30-year period showed that the incidence of stroke reduced despite an increasing patient risk profile and that over half of strokes occurred postoperatively rather than intraoperatively. Clinical presentation and surgical technique were specific to intraoperative stroke, but age and arteriosclerotic burden were associated with both intraoperative and postoperative strokes [20].

In Mao's study, seven variables (including advanced age, prior carotid artery stenosis, history of cerebrovascular disease/stroke, prior peripheral vascular disease, prior unstable angina, prolonged cardiopulmonary bypass time, and postoperative atrial fibrillation), representing high atherosclerotic burden, were found related to perioperative stroke events [19].

In the course of a surgical procedure, there are three different mechanisms that may trigger postoperative strokes: (1) embolic events, (2) defects in brain

perfusion, and (3) an inflammatory response, which can, in cases, intensify the other mechanisms [21].

Postoperative neurological complications, particularly those with a deficit, are especially destructive. Mainly, they are the outcome of macroparticle emboli associated with aortic atherosclerosis. It stands as a paradox that off-pump surgery has provided for a better recognition of the numerous pathophysiological processes, which might induce postoperative complications, most notably the neurological difficulties. It is now possible to measure the benefits that have become available by modified surgical practices and cardiopulmonary bypass (CPB). Modification of current cardiological therapies, with an increased use of antiplatelet agents and preoperative interventional procedures, may alter the surgical scene. As a result, many pathophysiological aspects may need further research [21].

1.6 Arrhythmia

Atrial fibrillation (AF) is one of the most common complications following cardiac surgery. It may happen in ~20–35% of cases after CABG surgery and in over 50% of patients upon valve surgery. AF after cardiac surgery is a primary cause of morbidity and mortality in patients [22].

In case preoperative atrial fibrillation is left uncorrected in patients undergoing CABG, it has been demonstrated that greater late cardiac morbidity and mortality as well as poorer long-term survival will follow. Thus, atrial fibrillation surgery should be considered at the time of CABG. It has yet to be determined whether the ablation of atrial fibrillation at the time of CABG can enhance prognosis, yet the present data support the idea of considering concurrent AF surgery [23].

Also, prior AF in patients who undergo CABG has been recognized as an incremental risk factor for time-related mortality. Even after being adjusted for risk factors of stroke, the patients with AF have a more substantial stroke risk of 2.6–4.5 times. The reason for the late increased mortality in patients with AF is not well known. Unquestionably, the higher chance of stroke and bleeding is explained by some of the difference; however, several studies also indicate that chronic tachycardia is linked with late mortality [24].

1.7 Diabetes mellitus (DM)

Patients suffering from DM bear a higher chance of adverse outcomes after CABG [25]. Thourani's study showed that DM has both worse in-hospital and long-term outcomes after CABG. The increased risk in DM patients can only partially be accounted for by demographic characteristics. Moreover, this study showed that diabetic patients were older and had more extensive coronary artery disease, a lower preoperative EF, a higher incidence of hypertension, prior myocardial infarction, heart failure, and class III–IV angina at the time of presentation [26].

In Zoltan Szabo's study, diabetic patients could undergo CABG in case they had an acceptable mortality risk, which was only slightly different from that found in nondiabetic patients. Cardiac grounds for early mortality were predominant in both diabetic and nondiabetic patients. However, the neurologic injury was evidence for a relatively higher proportion of early deaths in diabetic patients. Besides, midterm survival was noticeably compromised, especially in diabetic patients treated with insulin [27].

Calafiore's study showed that diabetes is an independent risk factor only for early cardiac mortality. Long-term survival in those who live the first 30 days does not differ significantly in diabetic and nondiabetic patients. In fact, the rates are very close [28].

A large 11-year-long nationwide cohort of patients undergoing a first isolated CABG in Sweden showed that the risk of death after CABG was double in patients with type 1 DM (T1DM) than patients without DM. Moreover, the cohort found that patients with type 2 diabetes mellitus (T2DM) had almost a similar risk of death as patients without diabetes. According to the cohort, patients with T1DM grow a high risk of adverse outcomes after CABG and should be intently followed up. Moreover, all possible measures need to be taken to reduce the risks of mortality or recurrent cardiovascular events in them [25].

Therefore, diabetic patients form a significant portion of the population undergoing surgical coronary revascularization.

1.8 Chronic kidney disease (CKD)

Creatinine levels are of a crucial role in on-pump coronary bypass grafting mortality. A worse prognosis may result from the combination of some risk factors and higher admission creatinine values. Moreover, lower admission creatinine values have been linked with a protective impact, even among elderly patients and those with a high cardiopulmonary bypass time [29].

Miceli's study indicates that occult renal dysfunction, i.e., normal creatinine level with impaired renal function, is connected with higher mortality and postoperative morbidity in CABG patients. A precise assessment of renal function, by estimating creatinine clearance and serum creatinine, can help detect patients at higher risks and categorize risks more accurately so that therapeutic strategies can be better optimized for these patients [30].

1.9 Chronic obstructive pulmonary disease (COPD)

Chronic obstructive pulmonary disease is associated with prolonged mechanical ventilation, prolonged length of stay, and postoperative complications such as pneumonia. It is similarly a principal predictor of long-term survival after CABG [31].

In one meta-analysis study (2019), COPD was not predictive of increased risks of postoperative mortality after CABG. Nevertheless, the study revealed that patients with COPD developed higher chances of developing postoperative morbidities, especially pneumonia, respiratory failure, renal failure, stroke, and wound infection. Therefore, when a patient with COPD requires CABG, caution should be taken in light of the higher risk for developing postoperative complications as with the respiratory system and others. High-quality RCTs are needed to confirm these results, however [32].

In Efird's study [31], COPD and prolonged length of stay were two of the several contributors to long-term postoperative mortality in CABG patients. In this regard, to reduce length of stay after CABG, it might be necessary to take aggressive treatment strategies with an aim for early weaning off of mechanical ventilation and prevention of reintubation among COPD patients. Our findings also have important implications for the long-term management of these patients and strategies for managing costs as the patient lives on [31].

1.10 Type of technique (off-pump versus on-pump)

Many studies have investigated the outcomes of off-pump and on-pump CABG. Nevertheless, their results are contradictory, and the advantages and disadvantages of the two methods are not clearly explained [33, 34]. Some studies have argued for the superior outcomes of off-pump CABG, primarily as concerned with short- and long-term mortality rates and complications. However, some other

studies have reported no significant differences between the two techniques [35, 36]. As an example, in a meta-analysis of mid- and long-term outcomes (2014), off-pump and on-pump CABG conferred similar midterm survival rates. On-pump CABG, however, was connected with better chances of long-term survival [36].

According to the results of Amouzeshi's study, the outcomes (e.g., death, myocardial infarction, rehospitalization, and normal physical activity) were not significantly different between off-pump and on-pump CABG in patients who underwent primary isolated non-emergent CABG during a 6-year follow-up phase [15].

In Raja's study, off-pump CABG versus on-pump CABG is correlated with comparable short-, mid-, and long-term mortality, similar organ protection, and fewer distal anastomoses. The available evidence cannot, nonetheless, substantiate all concerns about the safety and efficacy of off-pump CABG [37].

1.11 Addiction

Opioids are generally used as anesthetic agents. Long-term application of opioids can lead to analgesic tolerance via an unclear mechanism. Thus, addicted patients may require higher opioid doses [38].

Opiate addiction in CABG patients is of relatively high prevalence. Some studies indicate that drug addiction increases postoperative bleeding and risks of readmission in patients undergoing CABG. Besides, drug addiction together with pain suppression and changes in the endocrine system and cytokines can alter the process of wound healing in patients undergoing surgery [39].

Nemati's study showed that inhalational opium addiction is linked with higher bleeding after CABG. Given the overwhelming number of individuals with opium addiction who might need CABG in countries where opium addiction is widespread, cardiac surgeons need to consider these patients as being at high risk for major complications after surgery [40].

Given the fairly high prevalence of opium abuse among patients undergoing cardiac surgery and its potential prediction of AF after cardiac surgery, cardiac surgeons need to take better preventive measures when planning surgery for opium addict patients [22].

1.12 Ejection fraction

In patients undergoing CABG, the grade of left ventricular EF impairment, which reflects a decreased amount of contracting myocardium, stands as a recognized risk factor for poor short-term and long-term prognoses [41].

Patients with low EF are at higher risks of ventricular arrhythmia, sudden death, and deteriorating heart failure because of recurrent ischemia. In patients with low EF, CABG is demonstrated to be superior to medical therapy alone, leading to significant clinical enhancement and improved long-term survival [42].

Pieri's study [43] showed that moderate-to-severe left ventricular dysfunction is a typical finding in the general population undergoing cardiac surgery. Those with reduced low preoperative left ventricular EF undergoing cardiac surgery carry a high risk of postoperative complications as well as a higher mortality rate. However, the operation can be performed with a comparatively low mortality rate [43].

Haxhibeqiri-Karabdic's study [44] showed that in patients with left ventricular dysfunction, CABG could be performed safely with improvement in life quality and left ventricular EF.

Developments in preoperative management, enhancements in surgical techniques, application of off-pump CABG, advances in cardiac anesthesia, and

improvement in intensive postoperative care have led to a decreased mortality rate in patients with low EF operated by off-pump CABG [42].

Inamdar's study [42] revealed that in patients with coronary artery disease and low EF, off-pump CABG could be performed as a relatively safe procedure. It results in good midterm survival, improved left ventricular function, and enhanced overall life quality [42].

Amouzeshi's study [45] showed that even though an EF below 30% is an independent risk factor of mortality, proper care could minimize mortality after CABG. Besides, the study suggested inquiring into the impact of length of time after surgery and variables such as postoperative hospital care, surgical technique, the surgeon himself, and patient self-care training in more hospitals. It is necessary to note that the mortality rate of 10% in patients with EF below 30 and 5% in patients with EF above 30% in this investigation is quite satisfactory according to global standards [34].

Moreover, it is critical to have a careful preoperative selection and operative management, including optimal strategies of myocardial preservation for patients with low EF undergoing cardiac surgery [45].

1.13 Transfusion of blood products

Transfusion of blood products in patients undergoing CABG is linked with higher mortality and morbidity [46]. A few studies have revealed an association between blood transfusion and lower long-term survival after CABG [47].

Van Straten's study revealed that the number of transfused RBC is an independent predictor of early but not late mortality after CABG. Compared to the expected survival, receiving no RBC improves the patient's long-term survival, whereas receiving three or more units of RBC decreases the patient's survival significantly [46].

Mikkola's study showed that transfusion of any blood product is connected with significantly increased risks of all-cause and cardiac mortality after CABG. Such risks seem to be confined to the early postoperative period and decline later on. The perioperative use of fresh frozen plasma or Octaplas, from among blood products, appears to be the primary predictor of mortality [47].

These findings suggest that patient blood management is of extreme importance in enhancing postoperative outcomes, even in low-risk patients undergoing CABG [48].

2. Conclusions

In addition to cardiac-related and operation-related factors, patient-related contributors including senior age, comorbidity, female gender, and clinical preoperative situation can affect the clinical outcome of patients after CABG. This surgical procedure is a multidimensional phenomenon. In this regard, cardiac rehabilitation/secondary prevention programs can play a critical role in enhancing the process of care and outcome of this growing high-risk group of patients.

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Conflict of interest

The authors declare no conflict of interest in this study.

Author details

Ahmad Amouzeshi[1] and Zahra Amouzeshi[2*]

1 Department of Cardiovascular Surgery, Atherosclerosis and Coronary Artery Research Centre, School of Medicine, Birjand University of Medical Sciences, Birjand, Iran

2 Faculty of Nursing and Midwifery, Atherosclerosis and Coronary Artery Research Centre, Birjand University of Medical Sciences, Birjand, Iran

*Address all correspondence to: amouzeshiz9039@gmail.com and amoozeshiz9039@bums.ac.ir

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