Reoperative Coronary Artery Bypass Grafting: Review of Changing Pattern and Outcomes

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Abstract

Reoperative coronary artery bypass grafting (CABG) prevalence had markedly changed over the last decades. This change had been also noticed in patients' risk profile and outcomes. The aim of this review is to highlight large multi- and single-center studies investigating the change in pattern, techniques, and outcomes of reoperative CABG globally. It is meant to be a reference that can help cardiac surgeons for a better understanding of our current situation with this challenging operation.

Keywords: Reoperation; Redo; Coronary artery bypass grafting; CABG; Coronary artery diseases

Abbreviations: CABG: Coronary Artery Bypass Grafting; IABP: Intra-Aortic Balloon Pump; PTCA: Percutaneous Transluminal Coronary Angioplasty; STS: Society of Thoracic Surgeons; ITA: Internal Thoracic Artery; LAD: Left Anterior Descending Artery; ASCTS: Australasian Society of Cardiac and Thoracic Surgeons

Introduction

Since coronary artery bypass graft (CABG) surgery was introduced for clinical practice in the 1960s, it has demonstrated its efficiency to improve symptoms and prognosis in patients with the advanced coronary atherosclerotic disease [1]. As CABG patients are getting older and living longer, reoperative CABG surgery has become an integrative part of the cardio-surgical daily practice presenting significant challenges in technical and decision-making aspects [2].

A number of improvements have been made in the pre-, intra-, and postoperative management of reoperative CABG patients over the last decades. These improvements have included technological developments as well as the increased experience of the teams treating these patients (cardiology, anesthesia, intensive care, and surgical teams). Preoperative imaging with computed tomography is one of the most important preoperative improvements that has helped much with operative planning [3]. Also, the use of intraoperative transesophageal echocardiography has facilitated placement of retrograde cardioplegia, peripheral cannulation and intra-aortic balloon pump (IABP) [4]. However, the effect of all these improvements on the outcomes of reoperative CABG is masked

by the change in the risk profile of the patients. Although the prevalence of reoperative CABG has decreased, the risk profiles of the patients have increased [5-7].

Materials and Methods

Search strategy and study selection

A systematic literature search was performed through PubMed for studies published on outcomes of reoperative CABG. Keywords used in the search included MeSH terms: reoperative coronary artery bypass grafting, incidence, patient characteristics, trend, pattern, and outcome.

The "related articles" function was used to broaden the search and all abstracts, studies, and citations scanned were reviewed. The reference lists of articles found through these searches were also reviewed for relevant articles.

Inclusion and exclusion criteria

The inclusion criteria were: addressing reoperative CABG incidence, patient characteristics, and outcomes. Only the studies with a number of reoperative CABG patients more than 100 patients were included. However, studies comparing

deferent techniques of reoperative CABG like: off-pump versus on-pump, or thoracotomy versus re sternotomy were excluded. In this review, we present both multi- and single-center studies on trends and outcomes of reoperative CABG (Table 1).

Table 1: Previous Studies of Reoperative coronary artery bypass grafting (CABG).

Study	Place	Time Interval	Number of Reoperative CABG	Percentage of Reoperative CABG to overall CABG	Hospital Mortality
Ghanta et al. [5]	Multicenter study USA	2000 - 2009	72,322	6% (2000)	6.1% (2000)
				3.4% (2009)	4.6% (2009)
Yap et al. [15]	Multicenter study Australia	2001 - 2008	458	3.40%	4.80%
Weintraub et al. [21]	Single center study Emory University Hospital, Atlanta, USA	1975 - 1993	2030		7%
Christenson et al. [23]	Single center study Geneva, Switzerland	1984 - 1994	594	18.80%	9.60%
Noyez et al. [22]	Single center study Nijmegen, Netherlands	1987 - 1998	541		6.70%
van Eck et al. [16]	Single center study Nijmegen, Netherlands	1987 - 2000	582	8.50%	7.2%(overall)
					11% (1987-1991)
					6.4% (1992-1995)
					4.2% (1996-2000)
Yau et al. [6]	Single center study Toronto, Canada	1982 - 1997	1230	6%	6.80%
Spiliotopoulos et al. [7]	Single center study Toronto, Canada	1990 - 2009	1204	7.2% (1990-1994)	4.7% (1990-1999)
				2.2% (2005-2009)	3.8% (2000-2009)
Di Mauro et al. [19]	Single center study Torino, Italy	1994 - 2001	239	6.30%	4.20%
Ngaage et al. [20]	Single center study United Kingdom	1998 - 2006	154	5.60%	4.8% (1999-2001)
					2.8% (2002-2006)
Colkesen et al. [18]	Single center study Adana, Turkey	2010 - 2014	109	7.90%	4.60%
Yamamuro et al. [24]	Single center study Cleveland Clinic	1983 - 1993	739 elderly		7.60%
Lytle et al. [11]	Single center study Cleveland Clinic	1988 - 1991	1663		3.70%
Sabik et al. [12]	Single center study Cleveland Clinic	1990 -2003	4,518	21%	4.40%

Results

Incidence

Coronary reintervention after CABG has been common over the last decades. Sabik et al. [8] actively followed up 26 927 primary CABG patients at Cleveland Clinic. They found that patients' freedom from reintervention was 73%, 60%, and 46% at 15, 20, and 25 years after the first operation respectively. This means that more than half of primary CABG patients will have coronary reintervention if they lived for 25 years after the operation [8]. In order to adjust potential long-term benefits of CABG for attrition by death, Blackstone and Lytle examined the outcome of primary CABG patients at Cleveland Clinic also in light of three competing time-related events: death, reoperation, and percutaneous transluminal coronary angioplasty (PTCA). Their 12 years follow-up showed 58.6% of the patients were alive and without reintervention, while 26.6% were dead, 8.1%

had PTCA, and 6.8% had reoperative CABG [9]. In van Domburg et al. [10] 30-year follow-up study of 1041 primary venous CABG, coronary reinterventions were performed in 36% of the patients. 29.6% had reoperative CABG and 14.2% had PTCA. However, reintervention after 20 years was only PTCA [10].

Older studies showed increase in prevalence of reoperative CABG like Lytle et al. [11] study that mentioned marked increase in incidence of reoperative CABG compared with previous cohorts (436 patients from 1967 to 1978, 439 patients from 1979 to 1981, 625 patients from 1982 to 1984, 1009 patients from 1985 to 1987, and 1663 patients from 1988 to 1991) [11]. The largest single-center study on reoperative CABG was done by Sabik et al. [12] at Cleveland Clinic from 1990 to 2003 including 4,518 reoperations. Although the change in incidence of reoperative CABG was not mentioned in the study, one can notice from their presented tables that the number of reoperative CABG had decreased from around 500 in 1990 to around 200 in 2002 [12].

In contemporary studies; Ghanta et al. [5] used the Society of Thoracic Surgeons (STS) Adult Cardiac Surgery Database from 2000 to 2009 to analyze characteristics and postoperative outcomes of 72,322 isolated reoperative CABG patients from 1035 institutions. The percentage of reoperative to overall CABG volume decreased from 6.0% in 2000 to 3.4% in 2009 [5]. Also, Spiliotopoulos et al. [7] in Toronto General Hospital institution had done the most recent largest single-center study of changing pattern of reoperative CABG, including 1204 reoperative CABG patients from 1990 to 2009. The results showed that the prevalence of reoperative CABG had drastically decreased from 7.2% (1990 to 1994) to 2.2% (2005 to 2009) [7].

The decrease in the prevalence of reoperative CABG even with the large number of patients who had previous CABG can be attributed to multiple factors. The marked increase in the prevalence of previously performed PCTA on the native arteries or the grafts of reoperated on patients provides an obvious explanation for this downward trend of reoperative CABG [7]. Other factors that might have led to higher patients' freedom from reintervention include: improved surgical technique during primary operation using internal thoracic artery (ITA) to the left anterior descending artery (LAD) as a standard strategy, more effective risk factor control, and optimal medical therapy with statins and antiplatelet medications [13,14].

Patient characteristics

The characteristics of reoperative CABG patients usually show older age, more comorbidities, and worse presentation compared to primary CABG patients, that was shown in Ghanta's study of STS database. On the other hand, comparing the characteristics of reoperative CABG patients in 2009 with 2000 showed no significant change in age or gender. However, comorbidities like diabetes, hypertension, renal failure, chronic obstructive pulmonary disease, hypercholesterolemia, and cerebrovascular disease were more prevalent in 2009 than in 2000. Also, patients in 2009 had a worse presentation like congestive heart failure, left main disease, and myocardial infarction [5]. Spiliotopoulos et al. [7] showed in their study the deterioration in the preoperative risk profile of reoperative CABG patients over the years from 1990 to 2009. As the patients during the second decade had been significantly older, with larger body surface area, and with a higher incidence of diabetes, dyslipidemia, and hypertension. Moreover, preoperative atrial fibrillation, cerebrovascular accidents, left main stenosis, and peripheral vascular disease had been significantly more frequent. On the other hand, the mean interval between the first operation and the redo one had significantly increased in the second decade [7].

Another multicenter study of reoperative CABG was done by Yap et al. [15] using the Australasian Society of Cardiac and Thoracic Surgeons (ASCTS) Cardiac Surgery Database. The study included isolated CABG patients from 2001 to 2008.

458 patients underwent reoperative CABG. The risk profile of reoperative patients was significantly worse than primary patients due to a higher prevalence of elderly patients, patients with unstable angina, peripheral vascular disease, higher New York Heart Association class, worse left ventricular function, previous myocardial infarction, complete heart block, and more emergency operations. Similar results were shown in Sabik's et al. [12] study at the Cleveland Clinic [12,15].

Van Eck et al. [16] studied the change in profiles of 582 reoperative CABG patients from 1987 to 2000 in Netherlands. They divided the patients into three groups according to the date of the operation. Patients of the latest group showed a significant increase in mean age, kidney disease, and previous PTCA. Also, the time period between both operations had increased significantly, as well as, the number of patients with patent IMA graft [16].

Outcomes

Comparing outcomes in Ghanta's [5] study, postoperative observed mortality for reoperative CABG decreased from 6.1% in 2000 to 4.6% in 2009. But, it remained almost 2.5 times the mortality for primary CABG. This study was limited to STS Adult Cardiac Surgery Database information which captured neither the conduits used in the previous operation nor the interval between it and the current operation. STS database represents 1035 participating institutions with different protocols, teams, and experience. Also, using observed, predicted, and adjusted mortality in comparing the outcomes of reoperative and primary CABG in 2000 and in 2009 might not be enough to avoid the problem of comparing apples and oranges as those patients had different risk profiles. Using propensity scoring and comparing matched pairs instead might have been a more valid comparison [5,17]. In Yap's study, operative mortality for reoperative CABG was 4.8%. While, operative mortality for primary CABG was 1.8%. Using logistic regression model and after adjustment for differences in patient variables, reoperative CABG status remained a predictor of operative mortality [15].

In single-center studies, Spiliotopoulos et al. [7] showed in their study that comparing propensity-matched reoperative patients from 1990 to 1999 and from 2000 to 2009 did not show a significant change in operative mortality. However, the mean hospital length of stay had been significantly reduced. Also, their multivariate analysis of risk factors revealed preoperative shock, congestive heart failure, peripheral vascular disease, and age as independent predictors of operative mortality [7]. Another study was done by Colkesen et al. [18] in Adana, Turkey. They compared redo cardiac surgery procedures in general with primary ones including CABG and valve surgeries. They had 109 redo cardiac surgery patients between 2010 and 2014. Hospital mortality of redo patients was 4.6%, while it was 2.2% for primary cardiac surgery patients [18]. Also, Di Mauro et al. [19] analyzed early and late outcomes of reoperative CABG between 1994 and 2001.

Applying the propensity score, they matched 239 redo patients with 239 primary CABG patients. Early mortality was 4.2% for the redo group and 2.1% for the primary CABG group, without any significant difference. However, off-pump surgery in redo group had a positive impact on lower mortality than on-pump surgery (1.5% versus 5.3%) [19]. Ngaage et al. [20] studied the impact of preoperative symptom severity on the outcomes of reoperative cardiac surgery in Castle Hill Hospital, United Kingdom. Between 1998 and 2006, they had 154 reoperative CABG patients. Patients were divided into two groups, the first one from 1998 to 2002 and the second group from 2002 to 2006. The operative mortality was 4.8% for the first group versus 2.8% for the second group with no significant difference. Reoperation was not a determining predictor of major adverse postoperative event unlike age, pre-existing atrial fibrillation, duration of extracorporeal circulation, and concomitant valve procedure [20]. In older studies, hospital mortality was higher like in Weintraub and colleagues study of 2030 reoperative CABG patient at Emory University Hospitals, Atlanta, USA between 1975 and 1993. They had hospital mortality of 7%. Also, in Noyez's study in Netherland between 1987 and 1998 hospital mortality of reoperative CABG was 6.7%. In Christenson's study at Geneva, Switzerland 594 patients had reoperative CABG between 1984 and 1994 with hospital mortality of 9.6% [21-23]. In van Eck study, hospital mortality rate after reoperative CABG decreased significantly from 11% in the period from 1987 to 1991, to 4.2% at the period from 1996 to 2000 [16].

As for Cleveland Clinic, it has been one of the largest cardiac centers all over the world, having the highest rates of reoperative CABG they provided the largest single-center studies for the literature over time. Between 1983 and 1993, Yamamuro et al. [24] studied the risk factors and outcomes after reoperative CABG in 739 elderly patients (age ≥ 70). At this era, the incidence of reoperative CABG was increasing (26 cases in 1983, 123 cases in 1992). Hospital mortality rates were 7.6% [24]. Lytle et al. [11] analyzed the in-hospital mortality of 1663 reoperative CABG patients from 1988 through 1991 to study the influence of arterial grafts on the mortality. In this study, hospital mortality was 3.7% [11]. In Sabik's [12] study for reoperative CABG from 1990 to 2003, hospital mortality for patients having reoperative CABG was 4.4%. However, this rate decreased from 6% in 1990 to around 2.2% in 2000. Also, when the patients were stratified by date of operation, multivariable analysis demonstrated that after January 1, 1997, the risk of hospital death was the same in reoperative and primary CABG patients. For the propensity-matched patients, hospital mortality was still higher after reoperations (4.7%) than after primary operations (2.2%). However, when the propensity-matched patients were stratified by date of operation, multivariable analysis demonstrated that, after 1997 reoperation was not associated with increased risk of death. Then they concluded that surgical experience had neutralized the risk of reoperation attributable to its technical difficulty, while patient characteristics had a greater influence on hospital mortality [12].

Conclusion

The incidence of reoperative CABG has been decreasing over the last decade after reaching its peak in the 1990s. On the other hand, hospital mortality rates after reoperative CABG have been improving overtime despite the fact that the patients' risk profiles have been deteriorating.

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