Timing of bypass surgery in stable patients after acute myocardial infarction

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OBJECTIVES: To determine the optimal timing for bypass surgery in stable patients after acute myocardial infarction (MI).
BACKGROUND: Coronary artery bypass graft surgery (CABG) is a proven treatment for coronary artery disease. Because of the hypothesized risk of hemorrhagic transformation, it had become common practice to wait four to six weeks after MI. Recently, improvements in surgical and perioperative management, as well as an increase in pre-CABG in-hospital waiting times and excess burden on health care resources, have pushed surgeons to operate earlier. The optimal timing for a stable patient to undergo CABG after MI is unclear, because there have been no randomized trials to answer this question.
METHODS: The published literature comparing early versus late surgical revascularization procedures in stable post-MI patients was reviewed.
RESULTS: No randomized, prospective trials were found; however, several retrospective studies were identified. Most series examining Q wave MIs showed that mortality is higher in the early stages post-MI and progressively decreases with time post-MI. When studies examined non-Q wave MIs separately, there appeared to be less of a mortality difference between early and late surgical revascularization. There was a large disparity between the definitions of early surgery post-MI among the studies, some as early as 6 h and others up to eight days. Factors that increased mortality include abnormal left ventricular function and urgency of surgery, and some studies found risk models helpful to define increased risk after infarction. The possible increased risk of early surgery may be balanced against the potential for improved remodelling, improved quality of life and decreased hospital stay costs.
CONCLUSIONS: There is a need for a randomized, prospective trial examining the optimal timing for CABG in stable post-MI patients.

Key Words: *Bypass surgery; Early and late coronary revascularization; Myocardial infarction; Quality of life; Timing*

Le moment idéal du pontage chez des patients stables après un infarctus aigu du myocarde

OBJECTIFS : Déterminer le moment optimal pour procéder à un pontage chez des patients stables après un infarctus aigu du myocarde (IAM).
HISTORIQUE : Le pontage aortocoronarien est un traitement démontré de la coronaropathie. En raison du risque postulé de transformation hémorragique, il est devenu pratique courante d'attendre de quatre à six semaines après l'IAM. Récemment, les améliorations à la prise en charge opératoire et périopératoire, l'augmentation des temps d'attente en milieu hospitalier avant le pontage et le fardeau supplémentaire sur les ressources de la santé ont incité les chirurgiens à opérer plus rapidement. On ne connaît pas le moment idéal du pontage pour un patient stable après un IAM, car aucun essai aléatoire n'a répondu à cette question.
MÉTHODOLOGIE : On a passé en revue les publications comparant l'intervention de revascularisation rapide par rapport à l'intervention tardive chez des patients stables après un IAM.
RÉSULTATS : On n'a trouvé aucun essai prospectif aléatoire, mais plusieurs études rétrospectives. La plupart des séries portant sur l'IAM à onde Q indiquaient une mortalité plus élevée dans les premières phases suivant l'IAM, laquelle diminuait progressivement avec le temps après l'IAM. Lorsque les études évaluaient les IAM incomplets séparément, la différence de mortalité après une revascularisation rapide et une revascularisation tardive semblait moins grande. On remarquait une importante disparité entre les définitions de chirurgie rapide après un IAM dans les études, certaines ayant lieu dès six heures après l'IAM et d'autres, jusqu'à huit jours plus tard. Les facteurs qui accroissaient la mortalité étaient une fonction ventriculaire gauche anormale et l'urgence de l'opération, et certaines études ont trouvé les modèles de risque utiles pour définir un risque accru après l'infarctus. L'accroissement possible du risque d'une opération rapide peut être soupesé d'après le potentiel de meilleur remodelage, de meilleure qualité de vie et de diminution des frais d'hospitalisation.
CONCLUSIONS : Des essais prospectifs aléatoires sont nécessaires pour examiner le moment idéal du pontage aortocoronarien chez les patients stables après un IAM.

Myocardial infarction (MI) is the leading cause of death in Canada, the United States and the developed world. Coronary atherosclerosis accounted for more than one million hospital admissions per year in the United States alone in the 1990s, and this rate has more than doubled in recent years, resulting in more than 700,000 deaths annually (1). Over the past decades, a number of life-saving procedures and medications have been developed that have significantly lowered peri-infarct mortality (2): thrombolysis (3), primary angioplasty (4,5) and surgical revascularization (6), as well as the use of angiotensin-converting enzyme inhibitors (ACEIs) and beta-blockers (7,8). Since the early 1970s, emergency coronary artery bypass graft surgery (CABG) has been performed for impending or acute MI. Retrospective series have documented increased mortality in emergent bypass cases compared with those performed on an elective basis, although the results were better than for unstable patients treated with medical therapy only (9-13). In the 1980s, it was hypothesized that early reperfusion resulted in hemorrhagic transformation,

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which, in turn, resulted in infarct extension, impaired healing and scar formation (9). As such, it had become common practice to wait four to six weeks after a Q wave MI before surgical revascularization, a practice still followed by many surgeons.

CABG places a large burden on our limited health care resources, with resultant long waiting lists for patients. While waiting times of less than three months have been quoted for hospitals in the United States, the average waiting time for elective CABG is well over three months in Canada (14). Patients often wait in hospital after an MI for several weeks before they are allotted a date for CABG because of these backlogs, resulting in increased costs related to hospital stay. In some institutions, patients are discharged post-MI and are readmitted months later for surgical revascularization to help defray costs. There is little controversy regarding emergent surgery for acute MI complicated by a ruptured papillary muscle or acute ventricular septal defect, severe left ventricular (LV) dysfunction with refractory congestive heart failure, or refractory postinfarction angina. However, despite almost 30 years of surgical revascularization after acute MI, the precise timing of bypass surgery for the stable patient with indications for surgery remains controversial (13). No prospective, randomized study has been performed to compare the outcomes of early versus late CABG in post-MI patients. Several retrospective studies (16-28) have been performed; however, their results are often not generalizable. The present article reviews the literature comparing the outcomes between early and late CABG to better understand the optimal timing for surgical management of a stable patient post-MI.

METHODS

The published literature comparing early versus late surgical revascularization procedures in stable post-MI patients was reviewed. Medline, Ovid and Embase databases were searched for English articles published between 1972 and 2006. Key words included ‘coronary artery bypass grafting’, ‘early and late coronary revascularization’, ‘myocardial infarction’, ‘coronary ischemia’, ‘ventricular remodeling’ and ‘ACEI’. Both animal and human studies were included. The bibliographies of identified articles were also explored for additional sources of information.

RESULTS

Single-centre series

Over the past several years, a number of investigators have retrospectively studied the question regarding optimal timing for cardiac surgery post-MI (Table 1). Braxton et al (16) retrospectively compared the perioperative mortality of 58 patients with Q wave MI, 58 patients with non-Q wave MI and a control group of 225 patients operated on for angina without MI. The resulting data showed that a patient with a non-Q wave MI can undergo operation safely any time after MI, with a surgical mortality rate similar to that of the control patients (3.4% versus 2.4%, respectively; P not significant). A patient with a Q wave MI, however, had a 50% perioperative mortality if operated on within the first 48 h. After the first 48 h, surgical mortality fell to 7.7% (four of 52) over the remaining 40-day period. Hospital mortality for the Q wave acute MI group after 48 h, as well as the non-Q wave acute MI group versus the control group, was not significantly different. There was also no significant difference between the non-Q wave and control groups. The authors concluded that 48 h was an acceptable waiting time after a Q wave MI in stable patients.

Gertler et al (20) sought to answer the same question by retrospectively analyzing the charts of all patients who underwent CABG after MI. Their analysis showed a clear relationship between survival and the time lapse from the onset of infarction to operation, with a marked increase in survival in patients operated on more than 12 days after infarction among those with a transmural infarction. There was no significant difference in mortality in patients with a subendocardial infarction. They also concluded that surgery can be safely performed at any time after a nontransmural infarction, but that caution must be exercised in patients with a transmural infarction.

TABLE 1
Mortality data on single-centre, registry and multicentre series

Authors (reference)	Number of patients	Type of MI	Time post-MI	Mortality
Braxton et al (16)	283	Q wave	<48 h	50%
			>48 h	7.7%
	283	Non-Q wave	<48 h	No significant
			>48 h	difference
Gertler et al (20)	22	Subendocardial infarction	<12 days	No significant
			>12 days	difference
	22	Transmural infarction	<12 days	46%
			>12 days	0%
Voisine et al (21)	7219	All MIs	<6 h	19.2%
			6 h–24 h	9.8%
			1–7 days	8.6%
			8–30 days	3.2%
			>30 days	2.4%
Sintek et al (22)	530	All MIs	<24 h	4.4%
			24 h–48 h	0%
			48 h–72 h	0%
			3–7 days	2.1%
			8–30 days	1.4%
Deeik et al (17)	175	Q wave	5–7 days	No significant
	194	Non-Q wave	3–5 days	difference
Creswell et al (18)	3942	All MIs	<6 h	9.1%
			>6 weeks	2.9%
Kennedy et al (23)	793	All MIs (both stable and unstable patients)	<24 h	9.9%
			2–7 days	8.2%
			8–30 days	2.4%
Lee et al (19)	44,365	Q wave	<6 h	11.8%
			>1 day	2.8%
		Non-Q wave	<6 h	No significant
			>1 day	difference
VANQWISH (25) Trial Investigators	920	All MIs	8 days	11.6%
			30 days	3.7%
Hochberg et al (13)	174	All MIs	<1 week	46%
			>7 weeks	6%
Curtis et al (27)	993	All MIs	<24 h	18.6%
			>3 months	3.9%

MI Myocardial infarction; VANQWISH Veterans Affairs Non-Q-Wave Infarction Strategies in Hospital

Voisine et al (21) performed a similar review in their centre. They analyzed 7219 patients and classified them according to time since infarction (less than 6 h, 6 h to 24 h, one to seven days, eight to 30 days and more than 30 days). Their findings showed that operative mortality is highly and most significantly increased between 6 h and one week after acute MI and is safest more than 30 days after infarction. They also found that the age of the patient significantly affected mortality; patients older than 65 years of age demonstrated a higher mortality than younger patients. The investigators recommended avoiding CABG in patients 6 h to one week post-MI, particularly in elderly patients.

A smaller study was performed by Sintek et al (22), who studied 530 patients who underwent CABG after MI who and were divided into groups according to time interval since MI (group 1 – less than 24 h; group 2 – 24 h to 48 h; group 3 – 48 h to 72 h; group 4 – three to seven days; group 5 – one week to one month; and group 6 – control group). In their analysis, the timing of operation was not significantly associated with mortality. However, given their small sample size, the CI in groups 1, 2 and 3 were wide and, therefore, the findings in those groups were not as conclusive.

In another retrospective review, Deeik et al (17) studied three groups of patients over a two-year period between 1994 and 1996. Of the 214 patients undergoing elective, nonrepeat CABG, 155 had not had an MI (control), 39 had a non-Q wave MI and the remaining 20 had sustained a Q wave MI. In this study, a waiting strategy was used for stabilized patients suffering from an MI. Their goal was to have patients wait three to five days following a non-Q wave MI and five to seven days following a Q wave MI. According to the authors, waiting a mean of 4.9 and 6.2 days for non-Q and Q wave MI patients, respectively, before surgical intervention, results in a recovery rate comparable with that of patients undergoing elective surgery without MI. There was no significant difference in mortality among the three groups.

Creswell et al (18) studied a total of 3942 patients with isolated CABG over an eight-year period at a single institution. Of the 3942 patients, 2296 had a preoperative history of MI. No distinction was made between Q wave and non-Q wave MI. Operations were categorized as elective for patients who were hemodynamically stable at the time of operation and for whom the operation was undertaken as a procedure that could be scheduled more than 24 h in advance (3008 patients). All other operations were categorized as urgent or emergent. These included patients who were hemodynamically unstable at the time of operation and patients in whom operation was required for complications related to cardiac catheterization or failed percutaneous transluminal coronary angioplasty or other endovascular interventions. These also included patients in whom the operation could not be planned more than 24 h in advance (934 patients). Both elective and urgent or emergent groups were divided arbitrarily into five subgroups according to the time interval between MI and subsequent CABG (less than 6 h, 6 h to 48 h, two to 14 days, two to six weeks or more than six weeks) and were compared with the remaining 1646 patients (1316 elective and 330 urgent cases) who did not have a history of MI.

The operative mortality associated with CABG was not uniform among the patient groups (P<0.001). In comparing outcomes for all patients, the highest mortality was associated with operations undertaken early after MI (9.1% for patients undergoing operation within 6 h of MI), with a gradual decrease in mortality as the interval between MI and CABG increased (2.9% for patients undergoing operation more than six weeks post-MI). When all patients with an interval of at least two weeks between MI and CABG were grouped (1284 patients), the operative mortality rate of 3.7% was still greater than the rate for patients who had no preoperative history of MI (2.1%, 1646 patients, P=0.009). For most patient groups, including patients without preoperative MI, the operative mortality associated with elective operation was lower than for patients undergoing an urgent or emergent operation. The authors concluded that there appeared to be a decrease in morbidity and mortality associated with increasing time intervals between MI and CABG for time periods of as long as six weeks. As can be expected, however, the most important predictor of outcome in the early postoperative period was the urgency of the operation.

Similar conclusions were drawn by Kennedy et al (23) when they studied 793 patients who had CABG within 30 days of acute MI and included both stable and unstable patients. The study found that when all patients were included, mortality was highest in the early post-MI period (particularly within the first 24 h) and was higher for Q wave infarctions than non-Q wave infarctions. However, when logistic regression analysis was performed, the time interval from acute MI to CABG did not enter as a predictive variable. Instead, surgical priority contained most of the predictive information with patients requiring urgent CABG having a higher risk than those able to wait.

Registry data

More recently, Lee et al (19) retrospectively studied the data of 44,365 patients who underwent CABG as the sole procedure from 1993 to 1996 in New York from their cardiac surgery registry. A higher surgical mortality was found for those operated on within 24 h of MI, with mortality falling to 2.8% beyond one day. Those patients with transmural MI maintained a higher surgical risk for seven days beyond their MI. Of note, more than 50% of patients underwent their surgery 15 days after MI, clearly indicating that even with contemporary surgical practices, many cardiologists and surgeons elect to wait, or are required to wait due to lack of resources, for a relatively long period before revascularization (24).

Multicentre trials

There are no single or multicentre trials addressing the optimal timing of CABG post-MI. The only randomized data available secondarily addressing this question came from the Veterans Affairs Non-Q-Wave Infarction Strategies in-Hospital (VANQWISH) trial (25). The VANQWISH trial studied 920 patients with non-Q wave MI confirmed by cardiac enzymes and who were randomly assigned to early angiography and early revascularization or noninvasive testing with medical management and subsequent revascularization, if deemed appropriate (25). The study found that there were significantly more events in the early invasive management group before hospital discharge (36 versus 15), at one month (48 versus 26) and at one year (111 versus 85). In the subgroup analysis, almost all of the excess mortality in the early invasive group was attributable to the higher perioperative mortality ascribed to CABG. Additionally, in the invasive group, 30-day mortality was highest (11.6%) in those who underwent CABG within eight days of MI compared with a 30-day mortality of 3.7% in the group in which surgery was delayed by an average of 25 days.

Factors predisposing to increased mortality

Potential factors predisposing a patient to increased mortality postrevascularization in the MI population have been retrospectively investigated by several groups, with the hopes that identification of such factors would help in triaging patients who can safely undergo early surgical revascularization. In the 1980s, Hochberg et al (26) followed 174 patients who underwent surgical myocardial revascularization within seven weeks of a documented MI. Mortalities were categorized according to the postinfarction week in which the operation was performed. Patients had a mortality rate of 46% if they underwent surgery within one week of infarction versus 6% if they were operated on seven weeks after infarction. However, a marked difference in survival was noted when patients were classified according to ejection fraction (EF); patients with an EF of 50% or greater had significantly improved mortality rates across all categories, with only one late death. Among the 124 patients with an EF of lower than 50% there were 27 deaths, with steadily improving survival rates if revascularization was performed at a time more remote from the infarction. They concluded that surgical revascularization is safe at any time for patients with an EF of 50% or greater, but should be delayed at least four weeks in patients with an EF lower than 50%.

A similar study by Curtis et al (27), analyzing 993 patients who underwent CABG postinfarction, found a significant trend of increased operative mortality with recency of MI. However, when 18 risk factors were tested by stepwise logistic regression analysis, variables such as unstable angina, previous surgical revascularization, preoperative hypotension, nonelective surgery, preoperative cardiac arrest and female sex were the strongest predictors of mortality. They concluded that the increase in operative mortality in early CABG reflected a selection process in which patients with ongoing ischemia or unstable angina were selected for operation and tended to have increased mortality.

Finally, Zaroff et al (28) established a risk prediction model based on 71,774 subjects from the National Registry of Myocardial Infarction 2 database who underwent CABG. After excluding those who underwent emergent CABG, they still found a perioperative mortality rate (5.5% for the group) that was higher than that seen with elective CABG. In fact, 55% of patients had mortality rates between 4% and 13%, far greater than the 1% to 3% predicted mortality for elective CABG. With more than 21,000 women in the study, they detected an adjusted mortality rate of 1.58 for female sex. Other predictors of increased perioperative mortality were age older than 75 years (versus 65 years or younger), Killip class 2, 3 or 4, Q wave, history of congestive heart failure and previous CABG. There were, however, no data on the interval from MI to CABG. An accompanying editorial suggested that in the absence of a randomized, prospective trial, attempts should be made to try to stabilize even moderate- to high-risk patients and revascularize them as an 'elective procedure' (15).

Effect on cardiac remodelling

The recognition of cardiac remodelling as a pathological process post-MI has gained importance in the past 15 years (29,30). LV remodelling refers to the changes in ventricular geometry and function and is often a consequence of an MI (31-33). Remodelling after MI generally occurs as a compensatory response to the loss of contractile elements to help maintain the stroke volume in the face of a depressed LVEF, but with time, it eventually leads to heart failure. The process of LV enlargement can be influenced by infarct size, infarct healing and LV wall stress. The process is a continuum through structural and inflammatory consequences of healing, beginning in the acute period and continuing through and beyond the late convalescent period (34). Thrombolysis, by limiting infarct size, is of proven benefit in limiting early remodelling (35,36). In contrast, late remodelling involves myocytic hypertrophy and alterations in ventricular architecture, resulting in progressive LV dilation, and ultimately, LV failure (37). Multiple factors may, in fact, contribute to LV remodelling at different stages, and consequently, several interventions may limit remodelling. These include the use of ACEIs (38) and conferring late patency of the infarct-related artery by angioplasty or CABG (39). The assessment of the relative role and importance of these different determinants in the natural history of the remodelling process is of crucial importance for planning risk stratification and management strategies.

Patency of coronary arteries can also affect LV volumes and shape in patients with repetitive stunning or hibernating myocardium (40). Intervening at this stage of the remodelling process is thought to confer the greatest benefit, before the onset of irreversible necrosis or fixed LV dysfunction. Theoretically, these patients derive the greatest benefit from early revascularization (41). However, the degree of LV dysfunction also puts them at increased risk for surgery. The length of time it takes the myocardium to transform from the hibernating state to irreversible LV dysfunction is not known. Currently, there are no tests that can predict when such a transformation will occur, and clinicians are often left making somewhat arbitrary decisions in the hopes of salvaging myocardium before it becomes 'too late' (42).

A study by Bax et al (43) supports the theory of increased LV remodelling with increased waiting times. They evaluated 85 patients divided into two nonrandomly assigned groups based on early (one month or less) and late (more than one month) revascularization. They demonstrated that patients with ischemic cardiomyopathy and substantial viability benefited from early revascularization; LVEF improved from 28±9% to 40±12% ($P<0.05$) in the early group and remained unchanged in the late group (LVEF 27±10% to 25±7%; P not significant). They found no preoperative deaths in the early group and two in the late group, and on long-term follow-up, mortality was also higher in the late group (5% versus 20%, $P<0.05$). Unfortunately, this study did not specifically consider the length of time after MI that surgery was performed and was also not randomized. Therefore, although fear of late remodelling has been suggested as an impetus for early revascularization, there have been no randomized studies specifically investigating the effects of surgical revascularization, either early or late, on postinfarction remodelling.

Safety issues related to surgical delay

The issue of the safest time to operate brings into question not only the earliest possible safe time to operate after an MI, but also the safety of waiting. The studies described above have dealt, in detail, with the importance of waiting after an MI to prevent perioperative mortality and complications. That prespecified length of time remains to be defined, because the studies vary in their recommendations.

With regard to the safety of waiting, however, there are no data from randomized series regarding clinical events occurring in patients awaiting cardiac surgery. Two large, retrospective studies (44,45) from Ontario registries, involving 37,810 patients in total, have reported a waiting list mortality of less than 0.5%. In their study of 29,293 patients, Morgan et al (44) reported that patients waiting for CABG alone had a mortality rate of 0.4%, with one-third of deaths occurring within the first two weeks and the rest being randomly spaced through all time intervals, even beyond three months. The authors also confirmed that patients were at higher risk of death if they waited longer than recommended under the Ontario urgency rating score, a score that is based mainly on severity and stability of symptoms of angina, coronary anatomy from angiographic studies and results of noninvasive tests for risk of ischemia. Sampalis et al (46), in their prospective cohort of 266 patients, reported an adverse events rate of 32 in patients with a greater than 97-day wait for CABG versus 146 events in those with shorter waits ($P=0.005$). In another series of 2102 consecutive patients queued for CABG (47), aortic valve replacement or both, the mortality rate during the waiting period was 0.7%, but paradoxically, the incidences of postoperative complications and operative mortality were higher in the early surgery group versus patients who were operated on beyond the institutional standards for waiting (4.62% versus 1.81%). There was only one recurrent MI in the queue. Data from the study by Creswell et al (18), described previously, support these data. They found that the incidence of perioperative MI, permanent cerebrovascular events and

TABLE 2
Proposed benefits for early versus deferred coronary artery bypass graft surgery after myocardial infarction (MI)

Early	Deferred
Decreased hospital stay	Decreased mortality
Decreased cost	Decreased intensive care unit stay
Decreased left ventricular remodelling	Delay to allow for myocardial recovery
Improved quality of life	Low risk of mortality during waiting period
Risk of recurrent MI during waiting period	Rationalization of global resources

atrial fibrillation were more common among patients undergoing operation early after MI (P<0.01, P<0.05 and P<0.05, respectively). These studies suggest a low mortality rate in those whose surgery is significantly prolonged; however, it is possible that this risk is offset by a potentially lower perioperative risk of death seen in a number of studies described above.

The issue of safety of waiting for revascularization was also examined by Alter et al (48). They sought to determine whether admission to a Canadian hospital with onsite revascularization (invasive hospital) affected revascularization choice, timing and outcomes compared with community hospitals. Having excluded 524 patients who were revascularized urgently the same day of admission, they followed 15,166 nonrandomly assigned Ontario patients who underwent revascularization within the year after their index acute MI. Their findings showed that after adjusting for age, sex, socioeconomic status, illness severity, attending physician specialty and academic hospital affiliation, patients admitted to invasive hospitals had fewer cardiac readmissions before revascularization (41.5% versus 68.9%, P<0.001). Median revascularization waiting times were 12 days at invasive centres, versus 48 days in community hospitals (P<0.001), mostly due to the increased use of angioplasty in these centres. Despite the improved outcomes before revascularization, there were no outcome differences after revascularization. The authors concluded that the better outcomes in hospitals with onsite revascularization were attributable to the shorter waiting time from MI to revascularization. While this study seems to have supported an earlier invasive strategy, it did not specifically look at the use of CABG, and therefore, its results cannot be extrapolated to CABG waiting times.

Finally, Naylor et al (49) examined the risk of death while waiting for CABG in a large series of 21,220 registry patients from the Cardiac Care Network of Ontario. The standardized mortality ratio in the patients awaiting CABG was 2.92 (95% CI 2.29 to 3.55), while the standardized mortality ratio in the post-MI cohort was 3.84 (95% CI 3.54 to 4.14). Interestingly, the risk of waiting was unchanged as the length from index admission was reduced. The investigators concluded that patients awaiting CABG are at greater risk of death than the general population, but compared with other patients living with coronary artery disease, they are at similar or decreased risk of death.

Effect on quality of life

Very few studies have addressed functional status, quality of life and resource use associated with early versus late CABG post-MI. Data exist regarding New York Heart Association classification of cardiac symptoms after CABG, with the consensus indicating that CABG effectively relieves angina in most elderly patients (50-52). Certain studies have explored the issues of predicting morbidity post-CABG without delineating how long after MI the procedure was performed.

A study by Sampalis et al (46) is such a study. The investigators examined the impact of waiting time on the quality of life of patients awaiting CABG. They prospectively followed 266 patients from the time they were registered for CABG, classifying them into two categories for comparison; those with a short waiting period (97 days or less) and those with a long waiting period (more than 97 days). They noted that there were no differences in quality of life at baseline; however, immediately before surgery and six months after surgery, the group of patients with a longer waiting period had significantly reduced physical functioning, vitality, social functioning and general health, as measured using the Medical Outcomes Study 36-item Short Form questionnaire. Longer waits before CABG were also associated with an increased likelihood of not returning to work after surgery (47% versus 15%, P=0.08).

Effect on cost

The development of managed care and the desire to shorten hospitalization and contain costs has led surgeons to begin operating on uncomplicated patients as early as one or two days post-MI. In other cases in which waiting lists are much longer, patients have been discharged post-MI to await their CABG at home. Although there have been no studies directly examining the cost-effectiveness of early versus late CABG, several studies have suggested lower costs with earlier operations. Alter et al's study (48), described above, found that patients admitted to invasive hospitals consumed fewer hospital bed-days. However, it should be noted that these patients were more likely to be revascularized by angioplasty than by CABG. A study by Weintraub et al (24) comparing cost and outcome of coronary surgery between 1988 and 1996 found that despite increased disease burden, mean hospital costs decreased from US$22,689 in 1988 to US$15,987 in 1996, largely due to decreased length of hospital stay. In contrast, Creswell et al (18) detected a longer intensive care unit stay in patients with short time intervals between MI and CABG, a finding that was echoed in the study by Bax et al (43). Thus, the question of cost savings of early revascularization remains largely unanswered.

Current guidelines

The most recent guidelines published by the American College of Cardiology (53) state that in patients who have had an ST-segment elevation MI (STEMI), CABG mortality is elevated for the first three to seven days after infarction, and the benefit of revascularization must be balanced against this increased risk. They have given a class IIb recommendation that stable patients who have had an STEMI and who have incurred a significant fall in LV function should have their surgery delayed to allow myocardial recovery to occur. Interestingly, they have not specified the length of time that such a delay should occur. They also state that the committee believes that if stable STEMI patients with preserved LV function require surgical revascularization, CABG can be undertaken within several days of the infarction without an increased risk. The choice of wording and the lack of specific recommendations highlight the ambiguity of the issue.

CONCLUSIONS

It is clear that surgical revascularization plays an important role in decreasing long-term morbidity and mortality after acute MI; however, timing of this surgery in the stable patient remains unclear. Table 2 summarizes the proposed benefits of early versus deferred CABG after acute MI.

The data for increased use of primary angioplasty in treating acute MIs have often been extrapolated to the surgical field, in which cardiovascular surgeons are led to perform coronary revascularization earlier in the face of MI. However, it appears that such decisions lack strong evidence of benefit, and in fact, many retrospective series suggest that early revascularization may lead to increased mortality. Thus, the benefits of delaying surgical revascularization in stable post-MI patients may be more appropriate. But for how long is it safe to delay such a treatment, knowing that with time, poorly vascularized myocardium may be at risk of increased remodelling, especially in the face of continued risk of reinfarction to the patient? Additionally, current data suggest that very long waits result in reduced quality of life for patients, with the balance of cost potentially increasing with increased length of hospitalization. Unfortunately, virtually all studies published to date are non-randomized and are therefore subject to bias, so it is probable that higher risk subjects are referred for earlier surgery.

In the absence of randomized data, it appears to be safe to wait after MI in selected patients while maximizing medical therapy. However, the present review highlights the need for a prospective, randomized study to better address this issue. Until then, the decision of when to operate will remain in the hands of cardiologists and cardiovascular surgeons guided by personal biases, current guidelines, and the inherent waiting time dictated by local and regional resources.

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