

Effects of Seasonal Variations on Coronary Artery Surgery

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ABSTRACT

Background: In this study, we compared profiles and early results of patients who underwent coronary artery bypass graft surgery (CABG) during the winter season with those who underwent CABG during the summer season. We also investigated whether possible seasonal variations in performance of health care professionals had any effects on surgical outcome.

Methods: The data from patients who had undergone CABG surgery in the winter (group A) and summer (group B) seasons of the period from December 1998 to August 2001 were analyzed retrospectively. Preoperative, perioperative, and postoperative data were compared. Preoperative factors analyzed included sex, age, diabetes mellitus, hypertension, New York Heart Association status, unstable angina pectoris, and left ventricle ejection fraction. Perioperative factors included graft number, internal mammary artery use, cross-clamp time, and cardiopulmonary bypass time. Postoperative factors included mediastinal reexploration, blood use, inotropic support, intraaortic balloon pump support, perioperative myocardial infarctus, cardiac arrest, infection and other complications, duration of hospital stay, and early mortality.

Results: The preoperative demographic data were identical in the 2 groups, with the exception of incidence rate of hypertension (26.8% in group A versus 15.7% in group B, $P < .01$). The incidence rates were higher in group B than group A for postoperative infection (8.8% versus 5.2%, $P < .05$), mediastinal reexploration for bleeding (6.9% versus 4.2%, $P < .05$), and transfusion blood use (7.3 ± 6.2 U/patient versus 6.0 ± 3.9 U/patient, $P < .05$). There were no differences between the 2 groups in early mortality rates.

Conclusion: Despite the fact that frequency and occurrence of cardiovascular events traditionally have been reported to be higher in the winter than the summer, our data show no major differences in early surgical outcome among those patients who had undergone CABG in the winter or summer. We did not encounter any seasonal patterns. However, an interesting finding was that the patients who underwent surgery in the summer had a higher incidence of infection and bleeding.

INTRODUCTION

Several studies have shown that most of the systems in the body show daily (circadian), weekly (circaseptan), monthly (circamentual), seasonal, and yearly (circannual) variations. These variations might be important for individuals susceptible to disease. For example, it has been reported that the mortality rates from stroke and coronary heart disease increase during the winter [Woodhouse 1994, Pell and Cobbe 1999, Katz 2000, Horan 2001]. It also has been shown that coronary events, both fatal and nonfatal, are 20% to 40% more likely to occur in winter and spring than at other times of the year [Enquselassie 1993]. Furthermore, it has been suggested that seasonal mood swings (including winter depression) could play a role in mortality rates [Sher 2001]. Seasonal variations can also adversely affect the performance of health care professionals, leading to variations in hospital patient morbidity and mortality rates.

In this study, we compared the profiles and the early surgical results of patients who underwent coronary artery bypass graft (CABG) surgery in the winter with results of patients who underwent CABG surgery in the summer. We also investigated whether possible seasonal variations in the performace of health care professionals might affect surgical outcomes.

MATERIALS AND METHODS

Summer was defined as the months June through August and winter as December through February.

The study included patients who had undergone CABG during the winter (group A) and summer (group B) seasons of December 1, 1998, through August 31, 2001. Off-pump (beating heart) CABG and combined surgical cases were excluded.

Pertinent patient information was retrospectively studied, and factors analyzed included sex, age, diabetes mellitus, hypertension, New York Heart Association status, unstable angina,

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Table 1. Preoperative Patient Characteristics*

	Group A (n = 763)	Group B (n = 639)	*P*
Sex, n (% male)	636 (83.4%)	532 (83.3%)	NS
Age, mean ± SD (range), y	58.6 ± 10.0 (26-79)	9.0 ± 10.0 (25-85)	NS
Previous CABG surgery, n (%)	8 (1.0%)	7 (1.1%)	NS
Diabetes mellitus, n (%)	63 (8.3%)	43 (6.7%)	NS
Hypertension, n (%)	205 (26.8%)	100 (15.7%)	<.001
NYHA class	2.1 ± 0.5	2.2 ± 0.6	NS
Left ventricle ejection fraction, %†	54.4 ± 8.5	54.0 ± 8.3	NS
Unstable angina pectoris, n (%)	100 (13.1%)	97 (15.2%)	NS
Age >65 y, n (%)	238 (31.2%)	218 (34.1%)	NS

*CABG indicates coronary artery bypass graft; NYHA, New York Heart Association.
†Determined by ventriculography.

and preoperative left ventricle ejection fraction (EF). Results were also compared in relation to perioperative data (number of grafts, internal mammary artery use, cross clamping, and cardiopulmonary bypass time) and postoperative data (reexploration for bleeding, inotropic support, use of intra-aortic balloon pump support, perioperative myocardial infarction [MI], resuscitation in the intensive care unit, infection and other complications [eg, renal and cerebral], and length of hospital stay). The early (first 30 days) mortality rate was entered into the database.

Regardless of the nature and etiology, any infection (such as wound infections, mediastinitis, and lung infections) detected after CABG was categorized under "postoperative infections."

In our center, myocardial protection is done by an intermittent antegrade or a retrograde-plus-antegrade delivery method using blood or crystalloid cardioplegia infusion supplemented by topical cold application and moderate hypothermia (28°C-29°C). Proximal anostomoses on calcific aortas are performed using total cross clamp.

Statistical Analysis

The Student *t* test was used for continuous and normally distributed data, and the Mann-Whitney *U* test was used for categorical and nonnormally distributed data. Descriptive statistical values were expressed as mean ± SD, and *P* values (2-tailed) less than .05 were considered significant.

RESULTS

In our center, 2726 CABG procedures were performed between December 1, 1998, and August 31, 2001 (approximately 992/year). Of the 2726 surgeries, 763 (28.0%) were done in winter and 639 (23.6%) were done in summer.

The demographic data of winter and summer CABG cases are summarized in Table 1. History of hypertension was more prevalent in patients who underwent CABG in the winter than the summer (26.8% versus 15.7%; $P < .01$). Perioperative data are shown in Table 2. As Table 2 shows, there were no disparities in perioperative data between the 2 groups.

Postoperative data are shown in Table 3. In reference to these parameters, more group B than group A patients required mediastinal reexploration for bleeding (6.9% versus 4.2%, $P < .05$). Also, the group B patients required more blood transfusions than did the group A patients (7.3 ± 6.2 U/patient versus 6.0 ± 3.9 U/patient, $P < .05$). Moreover, postoperative incidence of infections was found to be higher in group B (56/639, 8.8%) than in group A (40/763, 5.2%) ($P < .05$). Distribution of these infections in groups A and B, respectively, according to type was: wound infections, 10 (25.0%) versus 36 (64.3%); pulmonary infections, 27 (67.5%) versus 7 (12.5%); and mediastinitis, 3 (7.5%) versus 13 (23.2%). Distribution according to isolated microbial agents in groups A and B, respectively, was: *Staphylococcus aureus* and *Staphylococcus epidermidis*, 23 (57.5%) versus 32 (57.1%); *Pseudomonas aeruginosa*, 5 (12.5%) versus 8 (14.3%); *Enterococcus sp*, 4 (10.0%) versus 7 (12.5%); *Escherichia coli*, 4 (10.0%) versus 6 (10.7%); fungus (*Candida*), 2 (5.0%) versus none (0%); unknown, 2 (5.0%) versus 3 (5.4%).

For the remaining parameters, there was no difference noted between the 2 groups.

There was no difference in early (first 30 days) incidence of mortality between the 2 groups: winter (group A), 2.1%; summer (group B), 1.7% (average annual mortality rate was

Table 2. Perioperative Variables

	Group A (n = 763)	Group B (n = 639)	*P*
No. of grafts, mean ± SD	2.4 ± 0.9	2.4 ± 0.9	NS
Internal mammary artery use	692 (90.7%)	573 (89.7%)	NS
Cross-clamp time, mean ± SD (range), min	54.8 ± 25.6 (14-184)	54.9 ± 23.9 (12-155)	NS
Cardiopulmonary bypass time, mean ± SD (range), min	93.1 ± 36.2 (27-275)	92.0 ± 36.0 (23-338)	NS

Table 3. Postoperative Parameters

	Group A (n = 763)	Group B (n = 639)	*P*
Inotropic support, n (%)	68 (8.9%)	51 (8.0%)	NS
Intraaortic balloon pump use, n (%)	46 (6.0%)	28 (4.4%)	NS
Perioperative myocardial infarction, n (%)	14 (1.8%)	8 (1.3%)	NS
Resuscitation, n (%)	32 (4.2%)	28 (4.4%)	NS
Infection, n (%)	40 (5.2%)	56 (8.8%)	<.05
Reexploration for bleeding, n (%)	32 (4.2%)	44 (6.9%)	<.05
Transfusion blood use, mean ± SD, U	6.0 ± 3.9	7.3 ± 6.2	<.05
Duration of stay in the hospital, mean ± SD (range), d	14.2 ± 7.9 (5-98)	13.3 ± 7.7 (5-86)	NS
Other complications,* n (%)	80 (10.5%)	58 (9.0%)	NS
Early mortality, n (%)	16 (2.1%)	11 (1.7%)	NS

*Includes rhythm disturbances and neurological, gastrointestinal, and lung complications.

1.8%). The mortality rate for all patients was the highest (2.4%) in January and the lowest (1.5%) in July.

The overall mortality rate for male patients was 2%, whereas the mortality rate for male patients in group B was 1.7% (*P* > .05). Mortality rates in patients aged 65 years and older were 9.7% in group A and 8.7% in group B (*P* > .05). There was no significant difference in mortality rates for patients with preoperative left ventricle EFs of less than 40% compared with patients with higher EF values (7.1% versus 6.8%, respectively, *P* > .05).

DISCUSSION

There are many reports of monthly, weekly, daily, and even ultradian (limited in hours) patterns of incidence of congestive heart failure. For example, it has recently been observed [Allegra 2001] that incidence of emergency department visits for congestive heart failure is higher in the winter months (December has the highest incidence and August the lowest), on Mondays (the lowest incidence is on Saturday), and during the hours of 8 AM to 3 PM. Similarly, cardiac mortality shows a peak in the cold season (December to February), on Mondays, and in the early morning hours (after awakening and arising) [Nicalou 1991, Willich 1998].

What triggers an episode of MI remains an enigma. However, it is reasonable to expect a stronger association than chance alone between external triggers and onset of MI and sudden cardiac death. Variables such as temperature (excess cold or excess heat), stress, humidity, barometric pressure, diet, environmental factors (eg, air pollution), social factors (eg, vacations, social tasks), and physical activity might be important.

It has been shown that resuscitation is less successful in cold weather [Katz 2000]. It has also been shown that people who suffer cardiopulmonary arrest in winter have a significantly lower likelihood of surviving [Pell 1999]. Cordioli et al emphasize that sympathetic system changes in the elderly and the effects of cold on some hemostatic factors may be involved in excess winter mortality [Cordioli 2000].

Scherlag et al showed in an animal model that ventricular tachycardia, the most common cause of sudden cardiac death due to coronary artery disease (CAD), occurred more frequently on cold days. They further speculated that the etiology might be higher sympathetic tone or catecholamine levels [Scherlag 1990].

Body weight increases in winter because of both increased fat intake and less frequent physical activity. This weight increase can be an important risk factor. However, Mustad et al suggest that a diet-independent seasonal variation in parameters may be involved in coronary heart disease (CHD) risk status [Mustad 1996].

Increased air pollution might also play a role in CAD mortality during the winter [Schwartz 1995]. It has been reported that MI is more likely to occur during relatively cold and moist weather with low atmospheric pressure [Sarna 1977]. Another study, however, detected no significant seasonal variations in the incidence of cardiac mortality and sudden death in the desert region [Katz 2000].

During the period of this study (December 1998-August 2001), data on weather conditions such as dust (μg/m^3), temperature (°C), and humidity (%) were obtained from the city meteorologic office. These values did not vary significantly for the same seasons (winter and summer) for each year of the study (1999, 2000, and 2001) (data not shown). Therefore, we believe that there were no important environmental factors that might have affected our results.

Seretakis et al have shown that seasonal patterns in coronary mortality have changed (the winter/summer total death ratio has declined) with time [Seretakis 1997]. They speculated that these changes are attributable to gradual improvements in indoor and vehicular heating and airconditioning. These results suggest that decreases in the incidence of temperature stress could lead to reductions in the annual peaks in coronary events.

Persons highly affected by seasonal changes may be at increased risk for development or worsening of CHD. It has been reported that males are more susceptible to seasonal fluctuations, suggesting the presence of an adrogenic risk factor; however, this sex difference dissipates with increasing age [Douglas 1995]. In our study, neither sex nor advanced age had a significant impact on the results.

Seasonal fluctuations in double product (in men only) [Hermida 2001]; heart rate variability [Kristal-Boneh 1984]; plasma lipids, cholesterol and lipoproteins [Mustad 1996];

leukocyte count (highest levels in autumn) [Friedman 1990]; and fibrinogen and factor VII (highest in winter) [Woodhouse 1994] have been reported.

Systemic blood pressures also have been noted to have seasonal fluctuations. It has been noted that the rate of mortality due to hypertension is higher in winter than in summer. Our results support this finding.

Lower temperatures result in increases in fibrinogen, platelets, red cells, and plasma viscosity and a reduction in plasma volume [Keatinge 1984]. As a result, hematological parameters vary throughout the year. Several variations in fibrinogen might be induced by winter respiratory infections via activation of the acute phase response [Andreenko 1980, Woodhouse 1994].

Platelets also show circadian variations. Platelet aggregation rates tend to be higher early in the morning in healthy subjects with a history of CAD [Toffler 1987]. Horan et al propose that prothrombotic changes in the hemostatic system related to seasonal factors, such as ambient temperature changes, and winter acute respiratory tract infections may contribute to excess winter mortality [Horan 2001].

We administered more blood transfusions to patients during and after CABG surgery in summer than in winter. In addition, the frequency of reexplorations due to postoperative bleeding was higher in patients who underwent surgery in summer. We consider these results the most interesting of our study. Because of the lack of patient data in our archives, preoperative hematological parameters could not be compared, but we believe that seasonal changes in fibrinogen level and platelet counts were of paramount importance.

In the light of presented literature, it can be speculated that low incidence of bleeding in winter is attributable to the fact that the clotting system is better regulated and controlled and therefore more reliable and stronger in the winter. If we consider that the cardiopulmonary bypass procedure is a challenge for the whole body system, minor fluctuations in the hematologic system may be of major clinical importance.

Winter acute respiratory tract infections induce and exaggerate the inflammatory response in older adults.

Psychological depression increases the risk of cardiac mortality, independent of clinical indicators of disease severity [Hance 1996]. It has been suggested that winter depression–induced suppression of the immune system may contribute to the increase in winter of the incidence of and mortality from cardiovascular disease [Sher 2001].

Contrary to the literature, which suggests a higher incidence of infection in winter, we found the summer cases to be more prone to postoperative infections. There were no major differences according to infectious agents. However, the infections that were more common in winter than summer were pulmonary infections (67.5% versus 12.5%), and the infections that were more common in summer than winter were wound infections (64.3% versus 25.0%) and mediastinitis (23.2% versus 7.5%). The predominance of wound infections in summer might be secondary to multiple environmental factors such as high humidity rendering skin to be easily breakable, colonizing bacteria, and breaching of the protective skin barrier.

Factors Related to Health Care Professionals

Health care professionals are also adversely or positively affected by seasonal variations. There are very few reports in the literature regarding seasonal performance patterns of health care professionals. A noteworthy factor is the so-called July phenomenon, observed in teaching institutions, of purported errors, inefficiency, and negative outcomes during the summertime transition of more experienced to less experienced house staff.

In one study [Rich 1993], the July phenomenon was observed to affect the care of patients in the internal medicine department but not patients in the surgical department. Another study did not show any evidence of an increase in negative outcomes early in the academic year compared with the end of the academic year [Claridge 2001]. The authors suggest that a systematic approach to the diagnosis, resuscitation, and treatment of trauma prevented a July phenomenon.

We have not come across any other studies regarding the influence on CABG patients of the July phenomenon or other seasonal variations in performance of health care professionals. It is fair to say that complications and mortality rates are expected to be higher in the winter because health care professionals and patients are more vulnerable to mood swings and illnesses. In summer, their mood and health status are at more positive levels. However, during this time, other factors including the July phenomenon might have a negative effect on the quality and quantity of service. Therefore, the overall performance in the summer months might be slightly inferior to that expected.

In conducting this study, we did not encounter any significant differences in patient profile data or preoperative or perioperative parameters of patients who underwent CABG in winter or summer seasons. We noted, however, that patients who underwent CABG in summer suffered more bleeding complications (or perhaps less stable hemostatic systems) and infections after the surgery. It is difficult to say whether the July phenomenon was a factor in these results. Nevertheless, the bleeding tendencies we observed were comparable to those reported in the literature.

Our results suggest that patients scheduled for surgery in summer months require a little more attention. In particular, patients who require major surgery or whose coagulation profiles are in the critical limits might need more delicate preoperative preparation and surgical hemostasis.

Future prospective and retrospective studies regarding this subject will serve the application of *chronobiology* to surgical subspecialities.

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