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Outcome Evaluation of Coronary Artery Bypass Grafting Surgery Applying the EuroSCORE in a Caribbean Developing Country

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ABSTRACT

Background: The risk-adjusted outcome of coronary artery bypass grafting (CABG) in Trinidad and Tobago was evaluated by applying the EuroSCORE scoring system.

Methods: A retrospective study was undertaken by reviewing the case notes of patients who underwent CABG from 2003 to 2008 under Caribbean Heart Care. Data collected included age, sex, smoking status, comorbidities, chronic pulmonary disease, extracardiac arteriopathy, neurologic disease, previous cardiac surgery, serum creatinine, active endocarditis, critical preoperative state, and mode of surgery. Predicted mortality was calculated with the EuroSCORE, the model was calibrated by Hosmer-Lemeshow analysis, and the discriminant function was analyzed by using the receiver operating characteristic (ROC) curve.

Results: We studied 1082 patients who underwent CABG, 75.6% of whom were of Asian Indian ethnicity. The overall mean (±SD) EuroSCORE was 2.87 ± 2.1. The predicted perioperative mortality rate was 2.3%, and the observed mortality rate was 1.2%. The overall standardized mortality ratio was 0.52. Eighty-six percent of the patients underwent off-pump CABG. Hosmer-Lemeshow analysis showed that the system calibrated well to our case mix (Hosmer-Lemeshow value, 6.87; degrees of freedom, 8; $P = .551$). The EuroSCORE discriminated patient outcomes well, as shown by the area under the ROC curve (0.78). Age and ethnicity did not influence the outcome.

Conclusions: The outcomes of CABG surgery patients are good in Trinidad and Tobago and are comparable to standards in developed countries when evaluated with the EuroSCORE. The proportion of patients undergoing off-pump CABG is high.

INTRODUCTION

Coronary artery bypass grafting (CABG) is the most common surgical procedure performed on the heart, with almost 1 million operations carried out worldwide every year [Keenan 2005]. Following the introduction of new surgical techniques and instruments, approximately a fifth of CABG procedures are now performed off pump, and this proportion is likely to increase [Shennib 2001]. Numerous studies have compared off-pump CABG with on-pump CABG surgery with respect to the complications of CABG surgery, costs, and short-term mortality. Many of these studies have found that off-pump CABG has superior outcomes, particularly with regard to short-term mortality and complication rates [Beneti 1991; Buffalo 1996]. Some other recent studies found no differences in outcome [Van Dijk 2007].

Cardiac surgery in Trinidad and Tobago started in 1993 at the Eric Williams Medical Sciences Complex, a tertiary-care teaching hospital affiliated with the University of the West Indies [Hariharan 2006]. Caribbean Heart Care (presently CHC-Medcorp Limited), Trinidad, is responsible for conducting different types of elective and urgent cardiac surgeries for all age groups in Trinidad and Tobago [Hariharan 2006]. The surgeries are done at 2 centers, the Eric Williams Medical Sciences Complex and the St. Clair Medical Centre, which is a corporate hospital offering tertiary-care services [Hariharan 2006]. Surgical teams from Venezuela, the United Kingdom, France, Italy, and Brazil have visited Trinidad and Tobago [Hariharan 2006]. Currently, there is an "in-house" team of surgeons. The services of the anesthetists, perfusionists, and nursing staff are provided locally [Hariharan 2006]. All patients are admitted postoperatively to intensive care units (ICU) under the care of an intensivist and are later transferred to the high-dependency units [Hariharan 2006].

Off-pump coronary artery surgery has been performed in Trinidad and Tobago since 1997, and >600 off-pump surgeries have been completed [Hariharan 2006]. The proportion of surgeries performed off pump increased from 15% in 2001 to 50% in 2002 and is continuing to increase, with present estimates being 80% to 85% [Hariharan 2006]. The overall mortality rate for off-pump CABG surgeries during the period from 1997 to 2002 was 2.6%, compared with 4.6% for on-pump CABG [Hariharan 2006].

EuroSCORE (European System for Cardiac Operative Risk Evaluation) is one of the common methods for evaluating the risk-adjusted operative mortality for patients undergoing

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cardiac surgery [Nashef 1999]. The EuroSCORE was developed with nearly 20,000 consecutive patients from 128 hospitals in 8 European countries. The EuroSCORE has been tested in other European hospitals and has been performing well. It has also been used in countries outside of Europe; however, to our knowledge there has been no published study to determine whether the EuroSCORE is a suitable model for the Caribbean region.

The Caribbean region consists of many different racial and ethnic groups, mainly of African and Indian descent. It may be worthwhile to apply models such as the EuroSCORE to assess the outcome of patients undergoing cardiac surgery, because the genetic risk factors and ethnic factors could be different from the European case mix. With this background, the objective of the present study was to apply the EuroSCORE model to evaluate the risk-adjusted outcome of CABG in Trinidad and Tobago.

METHODS

Approval was obtained from the Ethics Committee of the Faculty of Medical Sciences, The University of the West Indies, and from the authorities of Caribbean Heart Care. The study was designed as a retrospective chart review; hence, individual informed consent was waived. We enrolled all patients who underwent CABG at Caribbean Heart Care, Eric Williams Medical Sciences Complex, from 2003 through 2008. Patients who did not undergo CABG within the time frame of the study were excluded. The required data were obtained from patient records and were transcribed with a coded number to maintain confidentiality.

The demographic data recorded included age, sex, ethnicity, body mass index, and history of smoking. The presence of other comorbidities, such as chronic obstructive pulmonary disease, dyslipidemia, and hypertension, was noted.

The data collected for the EuroSCORE included the following: age; sex; the occurrence of chronic pulmonary disease, extracardiac arteriopathy, neurologic disease, and previous cardiac surgery; serum creatinine concentration; the occurrence of active endocarditis; and critical preoperative status. The additive and logistic EuroSCOREs were calculated to obtain the predicted mortality. The comparison of the actual observed outcomes of patients with the predicted outcome using the EuroSCORE was performed by calculating the standardized mortality ratio (SMR).

Descriptive analyses of the data were performed. Data were expressed as the mean and the SD or as the median and the interquartile range. The Mann-Whitney *U* test was used to analyze differences between variables for survivors and nonsurvivors. The independent Student *t* test and chi-square analysis were used to compare the variables for the major ethnic groups. The EuroSCORE was calibrated by Hosmer-Lemeshow analysis, and discriminant analysis was performed by applying receiver operating characteristic (ROC) curve analysis. Statistical significance (α level) was fixed at *P* values <.05. The Statistical Package for the Social Sciences (SPSS) for Windows (version 12; SPSS, Chicago, IL, USA) was used for data analysis.

RESULTS

We enrolled 1082 patients who underwent CABG during the study period. These cases included both on-pump and off-pump patients.

Table 1 summarizes the demographic data and comorbidities of all the patients. Male patients constituted 72.6% of the patients; 27.4% were female. Patient age ranged from 29 to 82 years (median, 58 years; interquartile range, 52-64 years). The ethnic composition of the population was as follows: Indo-Trinidadian, 75.1%; Afro-Trinidadian, 15.1%; other ethnicities (including mixed ethnicity), 5.6%.

Eighty-six percent of the patients underwent CABG off pump. Figure 1 shows the percentages of patients undergoing CABG according to the number of grafts undertaken.

The mean (±SD) additive EuroSCORE was 2.87 ± 2.1. Table 2 compares the survivors and nonsurvivors in the study with respect to different variables, such as age, EuroSCORE, ICU length of stay, preoperative ejection fraction, number of grafts, and predicted mortality. Mann-Whitney *U* tests showed statistically significant differences between survivors and nonsurvivors with respect to age, ICU length of stay, EuroSCORE, and predicted mortality.

The 2 major ethnic groups (ie, Indo- and Afro-Trinidadian) were also compared with respect to age, number of grafts, EuroSCORE, and predicted mortality. The independent Student *t* test was used to analyze the differences. The EuroSCORE and predicted mortality were significantly higher in the Afro-Trinidadian patients; however, a chi-square analysis showed that ethnicity was not a significant factor influencing mortality. Table 3 compares the ethnic groups.

The observed overall mortality rate was 1.2%, and the mean predicted mortality rate was calculated to be 2.3%. The ratio of these 2 values, the SMR, was 0.52 overall for all of the patients in our study. Table 4 presents the different risk groups and their mortality rates.

Hosmer-Lemeshow goodness-of-fit analysis was done to calibrate the EuroSCORE. (Hosmer-Lemeshow chi-square value, 6.87; degrees of freedom, 8; $P = .551$). An ROC curve analysis was performed to determine the discriminant ability of the EuroSCORE for the present case mix. The area under the ROC curve (AUC) was 0.78 (SE, 0.06; 95% confidence

Table 1. Overall Demographic Data and Comorbidities*

Age, y	58.2 ± 8.9
Male sex, %	72.6
Diabetes mellitus, %	61.5
Hypertension, %	66.8
COPD, %	16
Nonsmokers, %	71
Ex-smokers, %	15
Smokers, %	14

*Age data are presented as the mean ± SD. COPD indicates chronic obstructive pulmonary disease.

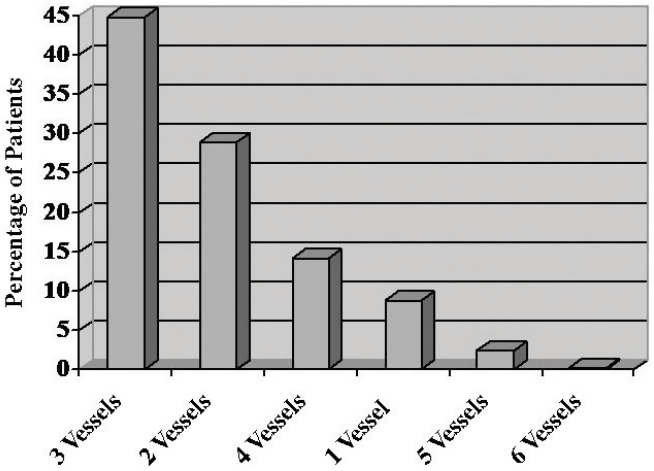

Figure 1. Percentages of patients according to the number of grafts undertaken.

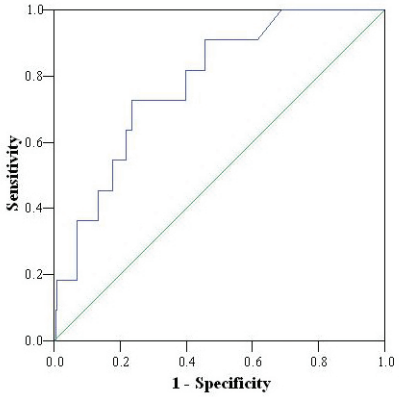

Figure 2. Receiver operating characteristic curve for the EuroSCORE.

interval, 0.66-0.90). Figure 2 depicts the ROC curve for the case mix in the study.

DISCUSSION

The major finding of the present study is the good perioperative outcome of CABG in Trinidad as evaluated with the EuroSCORE model. The outcome of CABG was not influenced by such demographic factors as age, ethnicity, or sex, or by such operative factors as the number of grafts per patient.

The ages of patients undergoing CABG in Trinidad were comparable to those in other countries. Our patients' ages covered a wide range (29-82 years); 21% of the patients were older than 65 years. The outcomes of CABG have not been different in the elderly age group. In fact, a study from Barbados has shown outcomes to be better in this age group [Hariharan 2005]. Although the EuroSCORE has age as an important factor determining outcome, there is doubt whether age is really an important factor [Mortasawi 2002]. In a study carried out in India, the mean patient age was 59 years [Meharwal 2003], compared with 58 years in the present study.

The majority of the patients in Trinidad who underwent CABG in the present study belonged to the Asian Indian ethnicity. There could be many reasons for this finding. This ethnic group is known to have coronary vessels with smaller diameters [Lip 1999]. It also has a high prevalence of comorbid illnesses, such as dyslipidemia, hypertension, and diabetes mellitus, which are risk factors for coronary artery disease [Hoogeveen 2001]. Although the higher proportion of Indians in the study may not imply categorically that coronary artery disease is much more prevalent in this ethnic group, it may imply indirectly that it is probable, because these patients were referred to Caribbean Heart Care from the Ministry of Health of Trinidad and Tobago.

The interesting finding of the study, however, was that despite the higher EuroSCORE and predicted mortality rate in the African ethnic group, the 2 ethnic groups were not significantly different with respect to mortality. The higher EuroSCORE and predicted mortality may be due to such factors as peripheral vascular disease, which is more prevalent in the African ethnic group. Even the proportions of patients with comorbidities in the ethnic groups were not significantly different.

In our study, 49% of the patients were in the low-risk EuroSCORE group (score of 0-2), compared with 31% reported in the original EuroSCORE study [Nashef 1999]. In that EuroSCORE study, a plurality (40%) of the patients were in the medium-risk category, a percentage comparable to that of the present study (39%). In all of the risk categories, however, the

Table 2. Comparison of Survivors and Nonsurvivors*

Variable	Nonsurvivors (n = 13)	Survivors (n = 1069)	*P*
Age, y	63.2 ± 7.6	58.1 ± 8.9	.036†
Preoperative ejection fraction, %	48.8 ± 13.3	54.2 ± 12.8	.19
No. of grafts	2.3 ± 0.9	2.7 ± 0.9	.08
ICU length of stay, d	2.1 ± 1.2	2.6 ± 0.8	.01†
Additive EuroSCORE	4.9 ± 2.5	2.9 ± 2.1	.005†
Predicted mortality, %	5.0 ± 3.9	2.2 ± 2.1	.001†

*Data are presented as the mean ± SD. ICU indicates intensive care unit.

†Statistically significant by the Mann-Whitney *U* test.

Table 3. Comparison of Variables for the Major Ethnic Groups*

Variable	Indo-Trinidadians (n = 813)	Afro-Trinidadians (n = 209)	*P*
Age, y	57.7 ± 8.7	59.1 ± 9.9	NS†
Preoperative ejection fraction, %	54.1 ± 12.8	53.9 ± 13.4	NS†
No. of grafts	2.8 ± 0.9	2.7 ± 0.9	NS†
Additive EuroSCORE	2.8 ± 2.0	3.2 ± 2.3	.03†
Predicted mortality, %	2.5 ± 2.1	2.8 ± 2.4	.01†
Observed mortality, %	0.95	1.1	NS‡

*Data are presented as the mean ± SD. NS indicates not statistically significant.

†Independent Student *t* test.

‡Chi-square test.

observed mortality rate in the present study was considerably lower than in the original EuroSCORE study (Table 4).

The proportion of patients who underwent off-pump surgery in the present study is among the highest reported in the literature. The report from India [Meharwal 2003] included patients who underwent their operations between 1997 and 2002, with 41% of the patients undergoing off-pump surgery in that setting. In a study conducted until 2007 in Italy, 25% of the patients underwent off-pump surgery [Parolari 2009]. Similarly, 25% of the patients in Barbados underwent off-pump surgery [Hariharan 2005].

The SMR value of 0.52 in the present study may mean that the overall risk-adjusted outcome of CABG in Trinidad is well within acceptable limits; however, this value may also imply that the EuroSCORE might have overestimated the mortality. Previous studies that used the EuroSCORE have arrived at this conclusion with a model similar to the present study. In a study conducted in Australia, the SMR was 0.32 [Yap 2006]. SMRs of 0.28 and 0.52 were reported for studies conducted in Korea and China [Youn 2007; Zheng 2009]. A study from Taiwan, another developing country, reported an SMR of 1.20 [Chen 2004]. The SMR is a well-recognized and validated measure for comparing the mortalities in different centers, although the mortality rate may vary between regions according to the case mix and the care offered. If one assesses mortality with the SMR, the mortality rate for CABG in Trinidad is comparable to that of most developed countries.

A prognostic model is calibrated by verifying the congruence between the predicted and observed outcomes for a given set of patients. This calibration is usually carried out by a Hosmer-Lemeshow goodness-of-fit test, which compares the predicted and observed outcomes in subgroups of patients belonging to deciles of risk. The lack of a statistically significant difference between predicted and observed outcomes ($P > .05$) implies that the model calibrates well. Discriminant analysis of a model determines a model's ability to categorize patients into 2 outcome groups, such as survivors and nonsurvivors. ROC curve analysis is a widely applied methodology for determining the discriminatory ability of a prognostic scoring system. The AUC (closer to 1) will indicate the robustness of the discriminating ability of the model.

In the present study, Hosmer-Lemeshow analysis showed that the EuroSCORE model calibrated well for the case mix in Trinidad. The AUC value (0.78) suggests that the system is a good discriminator of outcome for the Trinidad case mix. The AUC in the present study is similar to that of the original EuroSCORE study, lower than that of a study from Australia [Yap 2006], but better than that of a study from Taiwan [Chen 2004].

It is also possible that the EuroSCORE overpredicts mortality when it is applied in different settings. Investigators from Australia reported that the EuroSCORE too frequently overpredicted mortality in their setting and therefore developed their own score, the AusSCORE [Reid 2009].

There are some limitations to the present study. The most important is the retrospective design of the study, which limited the availability of data, such as ICU events, from the charts of the patients who underwent CABG during the study period; however, we were able to obtain sufficient data to calculate the EuroSCORE.

Nevertheless, in conclusion, the present study was reasonably able to validate the EuroSCORE model and evaluate the perioperative outcomes of CABG patients in Trinidad and Tobago. The overall outcome was comparable to that of the developed world. Trinidad and Tobago also has become

Table 4. Risk Groups according to the EuroSCORE and Their Mortality

EuroSCORE Risk Group	Percentage of Patients	Predicted Mortality, %	Observed Mortality, %
Low risk (0-2)	49	1.2	0.2
Medium risk (3-5)	39	2.6	1.4
High risk (>6)	12	5.8	3.1

one of the leading countries to adopt off-pump CABG for application in a large number of patients. People of Asian Indian ethnicity formed the major proportion of patients undergoing CABG.

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