Prognostic information in administrative co-morbidity data following coronary artery bypass grafting

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Abstract

Objectives: The aim of this study was to evaluate the prognostic information obtainable from administrative data with respect to 30-day mortality following coronary artery bypass grafting (CABG) and to compare it with the European System for Cardiac Operative Risk Evaluation (EuroSCORE) recorded in a clinical database.

Methods: We used a co-morbidity index calculated from administrative data in the Danish National Patient Register by means of all admissions 1 year prior to CABG. In addition, each CABG was categorised as being isolated or not, and acute or not. The prognostic power of the co-morbidity index was compared to that achieved using EuroSCORE from a clinical database comprising information on all patients treated with CABG in Denmark. The outcome was all-cause mortality within 30 days after CABG and the prognostic power was evaluated using logistic regression analyses.

Results: We identified 20,078 patients treated with CABG from 2000 to 2007 with a complete registration of the total additive EuroSCORE in the clinical database. The co-morbidity index carried significant prognostic information regarding 30-day mortality (c-statistic 0.81). The prognostic power of the co-morbidity index was equal to that of the EuroSCORE (c-statistic 0.79).

Conclusions: A standard co-morbidity index based on administrative data as well as on clinical data has proven equally useful for prediction of mortality amongst CABG patients.

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Keywords: CABG; EuroSCORE; Co-morbidity index; Prognosis

1. Introduction

Meaningful comparison of mortality rates following coronary artery bypass grafting (CABG) between hospitals or surgeons requires adjustment for a number of preoperative conditions (co-morbidity) and factors related to the surgical procedure. This information has been assembled in the EuroSCORE [1,2]. The calculation of EuroSCORE necessitates detailed information on each patient, which requires access to the patients’ charts and, in many cases, formation of a clinical database.

In Denmark, information on all patients undergoing CABG is entered into a clinical database, the Danish Heart Register (DHR), as well as the Danish National Patient Register (NPR). The NPR comprises administrative data that may be used to characterise each patient. In addition, the individual linkage to the Centralised Civil Register ensures a fixed period of follow-up. All Danish citizens have a unique civil registration number, which is used for linkage between registers at the individual level.

The aim of this study was to evaluate the prognostic information contained in a standard co-morbidity index estimated using administrative data with respect to 30-day mortality following CABG and to compare it with the additive EuroSCORE from a clinical database, to obtain a precise measure for analysing and predicting mortality.

2. Materials and methods

This study used three national registers in Denmark: a clinical database (DHR) comprising detailed clinical and prognostic information on each patient undergoing CABG; the NPR, which contains information on all hospital admissions.
since 1978, including diagnoses, surgery and administrative information; and the Centralised Civil Register comprising information on mortality. These registers were linked by the unique personal identification number assigned to every Danish citizen. All diagnoses were classified using the International Classification of Diseases (ICD) version 10.

2.1. Data from the clinical database (DHR)

We identified patients undergoing CABG from 2000 to 2007 in DHR. If a patient had surgery more than once during this period, only the first CABG was used. We recorded information on other surgical procedures at the time of CABG to conduct separate analyses of isolated CABG (CABG with no other concurrent thoracic surgery). All records of CABG in DHR include information on the total additive EuroSCORE. Data in DHR are entered perioperatively by the admitting physician and the surgeon.

2.2. Data from the administrative register (NPR)

In the administrative register NPR, CABG patients were identified using Nordic Surgery Classification codes KFNA-E. Other concurrent thoracic surgery was defined as simultaneous valve repair or replacement or surgery on the thoracic aorta. The co-morbidity index was compiled by primary and secondary diagnoses at admissions up to 1 year prior to CABG [3–5]. The relevant diagnoses were diagnoses of congestive heart failure (ICD-10; I09.9, I11.0, I11.3, I13.2, I25.5, I42.0, I42.5–I42.9, I43.x, I50.x), cardiogenic shock (ICD-10; R57), arrhythmia (ICD-10; I44.1–I44.3, I45.6, I45.9, I46.x, I47.x, I48.x, I49.x, R00.0, R00.1, R00.8, T82.1, Z45.0, Z95.0) and pulmonary oedema (ICD-10; J18.2, J81.x) for indications of the severity of heart disease, while diagnoses of malignancy (ICD-10; C00.x–C97.x), diabetes with complications (ICD-10; E10.0–E10.8, E11.0–E11.8, E12.0–E12.8, E13.0–E13.8, E14.0–E14.8), cerebrovascular disease (ICD-10; G45.x G46.x, H34.0, I60.x–I69.x), acute or chronic renal failure (ICD-10; N17.x, N19.x, R34.x, N18.x, T82.4, Z49.2, Z99.2) and chronic obstructive pulmonary disease (ICD-10; J40.x–J44.x, J47.x) indicated other co-morbidities. In addition, age and gender were used as explanatory variables together with information about isolated CABG and acute surgery or not. Data in NPR are collected by a secretary using the information about diagnoses and procedures provided in the discharge letter.

2.3. EuroSCORE

The EuroSCORE exists in two versions, a simple additive score, where the presence of each risk factor increases the total sum, and a logistic score, where the presence of each risk factor is weighted by a factor determined from the original test population [6]. Use of the logistic EuroSCORE requires information on each separate component of the EuroSCORE, that is, age, gender, serum creatinine, extracardiac arteriopathy, pulmonary disease, neurological dysfunction, previous cardiac surgery, recent myocardial infarct, left ventricular ejection fraction, pulmonary hypertension, active endocarditis, unstable angina, emergency operation, critical preoperative state, ventricular septal rupture, concomitant cardiac or thoracic aorta surgery. Up to the present, the DHR can only provide information about the total additive EuroSCORE since each component is not recorded.

2.4. Statistical methods

Discrete variables were presented as percentages, and continuous variables as medians with 25 and 75 percentiles. Comparisons of discrete variables were performed with chi-square-tests and of continuous variables with rank sum tests. We used logistic regression analyses to predict mortality based on the EuroSCORE and the co-morbidity index. The outcome was all-cause mortality within 30 days. Age was entered as 10-year age groups and each co-morbidity item was entered as a class variable. The age group 60–69 years was used as reference, being the largest and containing the mean. Very few patients had a EuroSCORE above 17 and these patients were all entered into the category 18+. EuroSCORE was treated as a class variable not assuming linearity. A EuroSCORE of 5 was used as the reference being the score of over 10% of the patients and closest to the mean. In both models, calendar year was entered to account for any period effect. Thus, gender, age, calendar year and each of the risk factors were entered in the logistic regression models. Only variables with independent statistically significant values (p < 0.05) were retained in the model by the use of backward elimination.

Cumulative mortality up to 30 days was estimated by the Kaplan–Meier method for five categories of EuroSCORE (0–2, 3–4, 5–6, 7–8 and 9+). For comparison, each part of the co-morbidity index was multiplied with the estimate achieved from the logistic regression. In this way, each part of the index was weighted according to the results of the logistic regression. The patients were then sorted by increasing risk according to this weighted index and divided into five categories with the exact same number of patients as in the EuroSCORE categories mentioned above. All statistical tests were two-sided and had a 0.05 significance level. All analyses were performed with SAS statistical software package version 9.13 (SAS Institute Inc., Cary, NC, USA).

2.5. Ethics

The Danish National Board of Health, the Danish Data Protection Agency and the board of the Danish Heart Register have approved the project, which was carried out in accordance to current rules of ethics and legislature. In Denmark, register-based studies do not require patient consent.

3. Results

Of the 21 544 CABG procedures identified in DHR during 2000–2007, 1388 (6.4%) were excluded due to missing values of EuroSCORE. The remaining 20 156 procedures performed on 20 078 patients, were included in this study. Isolated CABG accounted for 16 793 patients (83.6%) and 3285 (16.4%) had a CABG in combination with either valve surgery or other thoracic surgery. Within 30 days after CABG, 698 patients had
died. The number of patients and their demographic data by survival status at 30 days are displayed in Table 1.

There was a significant increased risk of 30-day mortality associated with increasing levels of EuroSCORE, and each of the components of the co-morbidity index except for malignancy and arrhythmias. Odds ratios independently associated with each risk factor from the co-morbidity index are presented in Table 2. The oldest age group, 80+, had the highest mortality, and the second oldest group had a remarkably lower mortality than the oldest. Female gender was associated with a moderately increased risk, whereas information about non-isolated and emergency surgery together with markers of failing heart and kidney function were associated with severely increased risk. The incremental increases in risk associated with increased levels of EuroSCORE are illustrated by the odds ratios in Table 3.

The prognostic power of the two models was expressed by the c-statistic. For 30-day mortality, the c-statistic was 0.81 for the co-morbidity index and 0.79 for EuroSCORE. Separate analyses of isolated CABG resulted in comparable estimates of the c-statistics (0.80 and 0.79).

The number of patients in the EuroSCORE categories 0—2, 3—4, 5—6, 7—8 and 9+ were 5112, 4946, 4401, 3103 and 2516, respectively. The cumulative mortality up to 30 days after CABG in the categories of EuroSCORE is illustrated by the odds ratios in Table 3. The model was further adjusted for calendar year (data not shown). c-statistic = 0.79.

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regardless of the source of the adjusting risk factors: the co-morbidity index or the EuroSCORE (results not shown).

4. Discussion

The main finding of this study was that a co-morbidity index based on administrative data predicted 30-day mortality following CABG and allowed meaningful comparison of institutional performance equal to the additive EuroSCORE registered in a clinical database. The c-statistics estimated by logistic regression ranged from 0.79 to 0.81 indicating good discrimination.

We had information on the additive EuroSCORE only, and the results may have been different if the logistic EuroSCORE was used. Shanmugam et al. found that the logistic score rendered a better estimate of the actual mortality risk; however, the prognostic information of the additive score was similar to that of the logistic score [7].

When the single elements of EuroSCORE were compared to the single elements of the co-morbidity index, it appeared that several items were identical. In addition to the identical items, EuroSCORE contains information on cardiac risk factors, such as left ventricular dysfunction, while the co-morbidity index contains information on non-cardiac related diseases, such as cancer. Each part of the co-morbidity index carried independent prognostic information except cancer and arrhythmia. The significance is quite clear, as cardiac risk factors mostly impact on the immediate outcome after surgery, while cancer impacts on the mortality on the longer term.

The comparison of clinical data and administrative data at the individual level is only possible in settings such as the Danish, where registers of good quality exist and provide possibilities of linkage at the individual level. The Danish Civil Registration number allows for numerous register-based analyses and register linkages. The number is used in all health care and administrative registers. For this study, we used an administrative register and a clinical database, both based on hospital recordings. In the administrative register, NPR, all administrative information is valid, as it is derived from the Centralised Civil Register. Information on diagnoses, on the other hand, may not be of the same quality and validity. Amongst the diagnoses included in the co-morbidity index are symptoms and findings (the R-chapter of ICD-10). This indicates that the quality of registration, and thus, the prognostic power of the co-morbidity index, can be improved.

The clinical database, DHR, is also based on hospital recordings; mortality is the exception, as information on mortality is derived from the Centralised Civil Register. The data quality for other variables may vary considerably. This is illustrated by the fact that 6.4% of operations were excluded due to insufficient data on EuroSCORE. Other weaknesses of the remaining data may explain the main finding of this study, namely that a compound variable based on administrative data has a prognostic quality similar to the surgeons’ risk assessments based on clinical data.

It is not clear whether our main finding can be attributed to the variance in registration quality of clinical data. It appears imperative to improve and harmonise the quality of clinical data to pursue further analysis of risk factors and mortality.

This study compares data on CABG patients from two registers. These data are, to a large extent, identical. Therefore, in the event that other factors not accounted for here had an impact on mortality, this would be the case for both datasets. It remains, however, a general weakness of register-based studies that confounding by items not accounted for could impact on results. Our results apply exclusively to CABG patients and cannot readily be extrapolated to other types of thoracic surgery. The co-morbidity index was originally developed for patients with acute myocardial infarction and seems appropriate to use in patients with ischaemic heart disease undergoing CABG. Risk adjustment for other procedures would require specific careful evaluation of each type of procedure, possibly with development of other co-morbidity indices. Furthermore, comparison of smaller units or even individual surgeons should be done with great caution, since decreased sample size is bound to decrease predictability using any co-morbidity index.

Other countries with registers of a comparatively high quality and individual linkage could make use of our finding that administrative data are applicable for predicting mortality in CABG patients. In less fortunate settings, however, the message could be the opposite: in the absence of good administrative data, a clinical database is just as good.

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References