Logistic or additive EuroSCORE for high-risk patients?

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Received 21 September 2002; received in revised form 21 January 2003; accepted 23 January 2003

Abstract

\textbf{Objectives:} To assess whether the use of the full logistic European System for Cardiac Operative Risk Evaluation (EuroSCORE) is superior to the standard additive EuroSCORE in predicting mortality in high-risk cardiac surgical patients. \textbf{Methods:} Both the simple additive EuroSCORE and the full logistic EuroSCORE were applied to 14,799 cardiac surgical patients from across Europe, of whom there were 4293 high-risk patients (additive EuroSCORE of 6 or more). The systems were compared for absolute prediction and discrimination (area under the receiver operating characteristic (ROC) curve). \textbf{Results:} Actual mortality was 4.72%. The logistic model was closer to this than the additive model (4.84% (4.72–4.94) versus 4.21% (4.21–4.26)). Most of this difference was due to high-risk patients where actual mortality was 11.18% and predicted was 7.83% (additive) and 11.23% (logistic). Discrimination was similar in both systems as measured by the area under the ROC curve (additive 0.783, logistic 0.785). \textbf{Conclusions:} The additive EuroSCORE model remains a simple “gold standard” for risk assessment in European cardiac surgery, usable at the bedside without complex calculations or information technology. The logistic model is a better risk predictor especially in high-risk patients and may be of interest to institutions engaged in the study and development of risk stratification.

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\textbf{Keywords:} EuroSCORE; Risk stratification; Cardiac surgery

1. Introduction

The European System for Cardiac Operative Risk Evaluation (EuroSCORE) has been favourably received and widely used since it was first introduced in 1999 \cite{1}. Based on a large and tightly controlled patient database \cite{2} drawn from across Europe, the system used logistic regression methodology to identify and give appropriate weight to various risk factors related to mortality in adult heart operations. In order to simplify the use of the system and to encourage risk assessment even in the absence of information technology, EuroSCORE was published as an additive system in which each risk factor is given a “weight” or a number of points which, when added, provide an estimate of the percent predicted operative mortality for a patient undergoing a particular procedure. The system has now been extensively tested and found to be valid throughout Europe \cite{3,4}, in North America \cite{5} and in Japan \cite{6}. There is evidence of rapidly expanding use of EuroSCORE worldwide. Nevertheless, because of its additive nature, the standard EuroSCORE has been found to underestimate risk in certain very high-risk patient groups \cite{7}. At the same time, there has been an exponential growth in the availability of information technology to hospitals and cardiac surgical units, and many have expressed a desire to use the full logistic equation of EuroSCORE rather than the approximation provided by the published, standard
Table 1

<table>
<thead>
<tr>
<th>EuroSCORE risk factors, their additive weights and beta coefficients</th>
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<tbody>
<tr>
<td><strong>Variable</strong></td>
</tr>
<tr>
<td>Age (continuous)</td>
</tr>
<tr>
<td>Female</td>
</tr>
<tr>
<td>Serum creatinine &gt; 200 µmol/l</td>
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<tr>
<td>Extracardiac arteriopathy</td>
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<tr>
<td>Pulmonary disease</td>
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<tr>
<td>Neurological dysfunction</td>
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<tr>
<td>Previous cardiac surgery</td>
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<tr>
<td>Active endocarditis</td>
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<tr>
<td>Critical preoperative state</td>
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<tr>
<td>Unstable angina</td>
</tr>
<tr>
<td>LVEF 30–50%</td>
</tr>
<tr>
<td>LVEF &lt;30%</td>
</tr>
<tr>
<td>Recent myocardial infarct</td>
</tr>
<tr>
<td>Systolic PA pressure &gt;60 mmHg</td>
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<tr>
<td>Emergency operation</td>
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<tr>
<td>Ventricular septal rupture</td>
</tr>
<tr>
<td>Other than isolated CABG</td>
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<tr>
<td>Thoracic aortic surgery</td>
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</tbody>
</table>

LVEF, left ventricular ejection fraction; PA, pulmonary artery; full definition of these variables are published [1] and can be seen on-line (http://www.euroscore.org).

additive model. The purpose of this study was to identify any difference in practice between the logistic model and the additive model and, if so, to determine which patient groups would be substantially affected by any such difference.

2. Methods

Both additive and logistic models were applied to predict mortality in 14,799 cardiac surgical patients from the EuroSCORE database. Using the additive model, risk was calculated by adding the relevant weights of any present risk factors to provide an estimate of predicted percent mortality (Table 1). Using the logistic model, predicted mortality was calculated using the equation:

\[
\text{predicted mortality} = \frac{e^{\beta_0 + \sum \beta_i X_i}}{1 + e^{\beta_0 + \sum \beta_i X_i}}
\]

where \( \beta_0 = -4.789594 \) (the constant of the logistic regression equation) and \( \beta_i \) is the coefficient of the variable \( X_i \) in the logistic regression data provided in Table 1. For age, a continuous variable, \( X_i = 1 \) if patient age \( \leq 60 \); \( X_i \) increases by one point per year thereafter: hence for age 59 or less \( X_i = 1 \), age 60: \( X_i = 2 \), age 61: \( X_i = 3 \), and so on.

Risk prediction for all patients was calculated using the additive and the logistic models. Absolute mortality prediction was then determined for the overall patient population and for risk subgroups and presented with 95% confidence interval. The two systems were compared for mortality prediction and for discrimination by calculating the area under the receiver operating characteristic (ROC) curve.

3. Results

For the overall group of 14,799 patients, there were 699 operative deaths giving an overall actual mortality of 4.72%. Logistic EuroSCORE prediction for the overall group was for a mortality of 4.84% (4.72–4.94) and did not differ significantly from actual mortality. Standard EuroSCORE predicted a significantly lower mortality of 4.21% (4.16–4.26). When analysed by subgroups of risk, it can be clearly seen that this difference is entirely due to under-prediction in high-risk patients (Table 2). In further subdivision of the high-risk group, the logistic EuroSCORE continues to predict mortality very accurately, despite the small number of patients in the extremely high-risk category (Table 3). The crossover point at which the two systems begin to diverge is at a predicted mortality of between 8 and 10% (Fig. 1). In terms of discriminatory power, both systems perform well with an area under the ROC curve of 0.783 (standard) and 0.785 (logistic) with a standard error of 0.01 for both values (Fig. 2).

4. Discussion

There are many reasons for predicting the risk of mortality in groups of cardiac surgical patients. These range from helping determine the indication for surgery and proper informed consent to allowing quality monitoring of surgeons and institutions. The standard or additive EuroSCORE works very well for most of these purposes and we continue to recommend it for the general purposes of risk stratification. The fact that the simple additive formula can be applied at the bedside without the use of sophisticated information technology and complex mathematics is a
strong advantage and undoubtedly helped EuroSCORE to achieve the success it has had so far. However, the true relationship between risk factors is not additive and the combined impact of two or more risk factors on operative risk may be more than the simple sum of their parts, especially when each factor has an important impact on outcome. Most surgeons intuitively know that combining the risk factors of, for example, age over 90, emergency repair of postinfarction septal rupture with poor left ventricular function and critical preoperative state would result in a situation of virtually zero survival yet EuroSCORE standard would only predict a mortality of 23% for such a patient. The logistic model, on the other hand, gives a more realistic prediction of 93% mortality. For most cardiac surgical populations, this discrepancy has little impact on risk prediction as the numbers of such patients are very small and the differences seen are not of a magnitude that is sufficient to justify the complex calculations needed to work out the logistic EuroSCORE. The logistic model, however, has a place in the following situations:

1. To calculate a precise and realistic risk prediction for a very high-risk patient, particularly where the indications for surgery are not absolutely clear.
2. To monitor quality of care in institutions where a substantial proportion of patients belong to very high-risk groups.
3. To help in the further study of risk modelling by groups and institutions with a scientific interest in the subject.
4. To carry out normal risk stratification in institutions with easy availability of site-wide, accessible information technology, especially where high-risk surgery forms a substantial part of the workload.

In conclusion, the standard EuroSCORE continues to be a simple and accessible-to-all “gold standard” of risk assessment. The logistic EuroSCORE offers small but distinct advantages over the standard model and its use may be of interest in certain hospitals and certain patient subgroups.

Fig. 1. Point of crossover at which there is divergence of prediction between the logistic and additive EuroSCORE models. When predicted risk exceeds 13, the models diverge widely (but only 0.8% of patients are in this risk group).
Fig. 2. Areas under the ROC curve for the additive and logistic EuroSCORE models: the curves are virtually identical.

Appendix A. Conference discussion

**Dr R. Schistek** (Wals, Austria): Why do you recommend to use just the standard EuroSCORE, because when we use it there is no difference between the standard and the logistic EuroSCORE. You can easily apply it to a database, as we did it. The information you give on your home page is detailed enough to apply the logistic score to any local database. So why should not everybody use logistic score?

**Mr Nashef**: We have tried to make it easy for everybody to carry out the logistic calculations, but I think we have to remember that there are still many hospitals that do not have access to the sophisticated information technology needed, and there are many surgeons who want to have something that they can work out in their mind when they are at the bedside or in the outpatient clinic. Now, with the exponential growth in IT availability, it may be that this will not be a problem. There is no doubt the logistic model is better, but it depends on technology, and you need to have the technology to use it.

**Dr Schistek**: So in another way, if it is possible to do the logistic, it is better?

**Mr Nashef**: I think so.

**Dr R. Frater** (Bronx, New York): Have you looked at changes in the risks with time? You base this on your original study, which was about six or seven years ago. Are the risks not changing in their consequence as you go ahead? It certainly was that way in New York; we found that it changes every year or so.

**Mr Nashef**: EuroSCORE is still at a stage where regular exercises of validation are being carried out, and the most recent in fact has only just been completed this year in the United Kingdom, and so far it still seems to work very well. But I fully agree with you that what we need to do is to perhaps have another data collection exercise in order to reassess the changing impact of risk factors and also the changing results.

**Dr Frater**: You know what happened in New York when we had as a risk factor intravenous nitroglycerin preoperatively?

**Mr Nashef**: Everybody was suddenly on intravenous nitroglycerin!

References


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