

Heart Mirror **HMJ** Journal

From Affiliated Egyptian Universities and Cardiology Centers

November 2007

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Heart Mirror Journal 2007;1(2);52-56; originally published online November, 2007

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Print ISSN: 1687-6652. Online ISSN: 1687-5958

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ORIGINAL ARTICLE

Risk Stratification Analysis of Operative Mortality in Patients Undergoing Mitral Valve Replacement

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Background The use of risk stratified mortality studies for analyzing surgical outcome in cardiac surgery is obviously a developing area. Unfortunately, outcomes research in valve replacement surgery has been relatively limited. Our purpose was to compare the performance of risk stratification models, Parsonnet and European System for Cardiac Operative Risk Evaluation (EuroSCORE) in our patients undergoing mitral valve replacement (MVR).

Patients & Methods From April 2003 to May 2007, 90 consecutive patients have undergone MVR using cardiopulmonary bypass and scored according to Parsonnet and EuroSCORE algorithm. Score validity was assessed by calculating the area under the receiver operating characteristic (ROC) curve.

Results Overall hospital mortality was 5.55%. In Parsonnet model, predicted mortality was 4.26% while in the EuroSCORE model, predicted mortality was 4.5%. Areas under the ROC curves were 0.715 in Parsonnet and 0.794 in EuroSCORE and it was statistically significant for the EuroSCORE. Also, the EuroSCORE has a higher specificity compared to the Parsonnet score.

Conclusions The EuroSCORE is more reasonable overall predictor of hospital mortality in our patients undergoing MVR compared to Parsonnet score. It can serve as a baseline for the development of a local risk model.

Keywords Mitral valve, mortality, thoracic surgery, risk factors.

INTRODUCTION

Cardiac surgery remains a very complex area for outcome prediction. Recently, analysis of patient outcome has gained increasing importance. The outcome to be measured must be relevant to clinicians and patients, easily recognized, and well defined (1).

Hospital or operative mortality has been acknowledged as the major indicator of performance in cardiac surgery (2), is the outcome most commonly measured by currently available risk scores and meets all of previously mentioned criteria.

It is well known that outcome following heart surgery is dependent on various preoperative patient characteristics (3) that may differ significantly between institutions and countries. It became obvious that comparison of absolute numbers, such as mortality rates, can give a misleading picture (4,5).

Several different scoring systems have been developed to predict mortality after adult heart surgery, to correct for differences in patient population and to allow comparison of actual outcome to predicted outcome (4,6-10). However, all have limitations and most of them focus on coronary artery bypass surgery (CABG). Unfortunately, outcomes research in valve replacement surgery has been relatively limited.

It was the purpose of our study to compare two commonly used preoperative risk scores (Parsonnet and EuroSCORE) for heart surgery with regard to their predictive values and clinical applicability for our patient population undergoing mitral valve replacement (MVR).

PATIENTS AND METHODS

The cohort of this study included 90 patients who had undergone MVR without concomitant procedures and scored according to Parsonnet and EuroSCORE algorithms during the period April 2003 to May 2007 in a university hospital. Mean age was 34.3 ± 11.4 years and 23.33% were males. We have collected preoperative patient characteristics and data were entered into a computerized database. The main outcome measurement was hospital mortality, defined as "death within the same hospital admission as operation, regardless of cause". Mortality was recorded from patient and hospital records.

Predicted hospital mortality rates were calculated automatically by computer software available at www.safar.org (11) by use of the logistic regression models of Parsonnet and EuroSCORE algorithms.

Abbreviations and Acronyms

CABG = coronary artery bypass surgery
MVR = mitral valve replacement
ROC = receiver operating characteristic

Risk prediction model

The Parsonnet score (4): 14 risk factors were chosen and an additive model was constructed, using the factors chosen, to calculate the probability of mortality within 30 days. The model allocates additive predicted mortality percentage points for 14 patient risk factors to give a “Parsonnet score” which is indicative of the per cent mortality for each patient (Table 1). For example, female gender (1), obesity >1.5 times ideal weight (3), diabetes (3), hypertension (3) etc. The logistic regression model is more accurate when combinations of factors exist. It gives the predicted mortality for each patient. They were calculated automatically by the software program. The population was divided into five clinically relevant risk categories according to Parsonnet score, (0-4%), (5-9%), (10-14%), (15-19%) and (20%±).

EuroSCORE(9): The simple additive EuroSCORE: EuroSCORE contains 17 risk factors that are weighted for the definitive scoring system: nine patient-related factors, four factors derived from preoperative cardiac status, and four related to the timing and nature of the operation performed (Table 1). The risk factors and the weights allocated to them are as follows:

Table 1. Investigated risk factors among risk scores.

Risk factor	EuroSCORE	Risk factor	Parsonnet score
Patient related factors:			
Age (over 60 years)	one per 5 years or part thereof	Age (years) 71-74 75-79 ≥80	7 12 20
Sex (female)	1	Female	1
Chronic pulmonary disease	1		
Extracardiac arteriopathy	2		
Neurologic dysfunction	2		
Previous cardiac surgery	3	First reoperation Second reoperation	5 10
Serum creatinine >200µmol/l	2	Dialysis dependent	10
Active endocarditis	3		
Critical preoperative state	3	Catastrophic state	10-50
Cardiac related factors:			
Unstable angina	2		
LV dysfunction		Ejection fraction%	
LVEF 30-50%	1	>50	0
LVEF <30%	3	30-49	2
		<30	4
Recent myocardial infarction (<90 days)	2		
Pulmonary hypertension (systolic PA >60mmHg)	2	Valve surgery Mitral PAP>60 mmHg Aortic Gradient >120mmHg	5 3 5 2
Operation-related factors:			
Emergency	2	Emergency	10
Other than isolated CABG	2	CABG with valve	2
Surgery on thoracic aorta	3		
Postinfarctional septum rupture	4	Diabetes Obesity >1.5 times ideal weight Hypertension Preoperative IABP	3 3 3 2

Age over 60 (one per 5 years or part thereof); female (1); chronic pulmonary disease (1); extracardiac arteriopathy (2); neurological dysfunction (2); previous cardiac surgery (3); serum creatinine (2); active endocarditis (3); critical preoperative state (3); cardiac-related factors such as unstable angina (2), LV dysfunction etc. [1 for moderate(LVEF 30–50%) or 3 for poor (LVEF <30%)]; recent myocardial infarct (2); pulmonary hypertension (2); operation-related factors such as emergency (2) etc.; other than isolated CABG (3); surgery on thoracic aorta (3); and postinfarct septal rupture(4). The system is additive: the predicted risk for a patient is calculated by adding the scores for existing risk factors to obtain an approximate predicted mortality index.

The full logistic version of EuroSCORE produces more accurate mortality risk prediction for each patient especially high risk patient. Both versions of the EuroSCORE were calculated automatically by the software program. The population was divided into five clinically relevant risk categories according to EuroSCORE, [0-2], [3-5], [6-8], [9-11] and [12+].

Probabilities of hospital death were compared with the actual outcome for each scoring system.

Statistical analysis

The data are presented as absolute numbers, mean + standard deviation or percentages. The validity of the Parsonnet and EuroSCORE to predict observed mortality was determined by calculating the area under the receiver operating characteristic (ROC) curve (12-14). The ROC curve is a plot of sensitivity against 1 - specificity and is generally regarded to be a good summary measure of the predictive ability of these types of algorithm. An area of 1 suggests a perfect predictor, 0.5 suggests a predictor that is no better than chance alone, and scores of between 0.7 and 0.9 are generally regarded as useful.

A comparison between observed and predicted mortality calculated by Parsonnet and EuroSCORE was done using Z test. A value of P<0.05 is considered statistically significant.

RESULTS

The prevalence of risk factors among the study population is shown in (Figure 1).

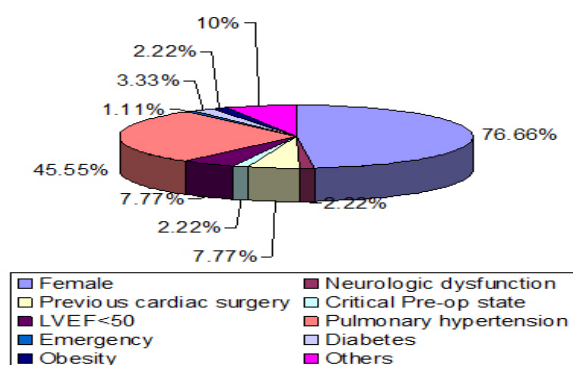


Figure 1. Distribution of risk factors among the study population.

Predictive ability of Parsonnet score and EuroSCORE:
ROC curves were plotted separately for mortality for each score. Both scores showed areas under the curve greater than 70%.

Areas under the ROC curves were 0.715 in Parsonnet score (Figure 2) and 0.794 in EuroSCORE (Figure 3) suggesting models of useful predictive ability.

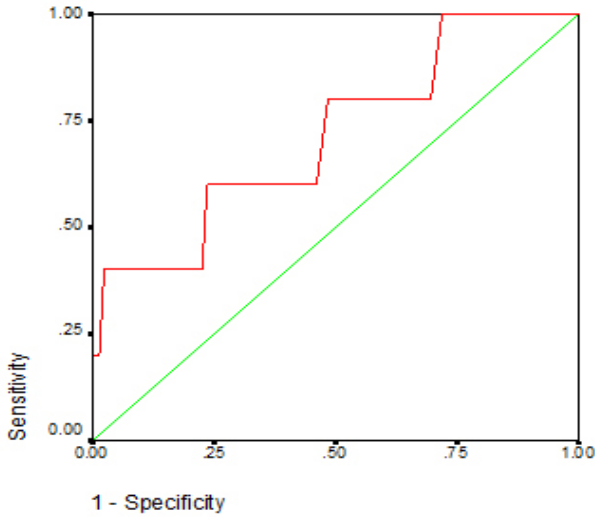


Figure 2. ROC curve for Parsonnet Score.

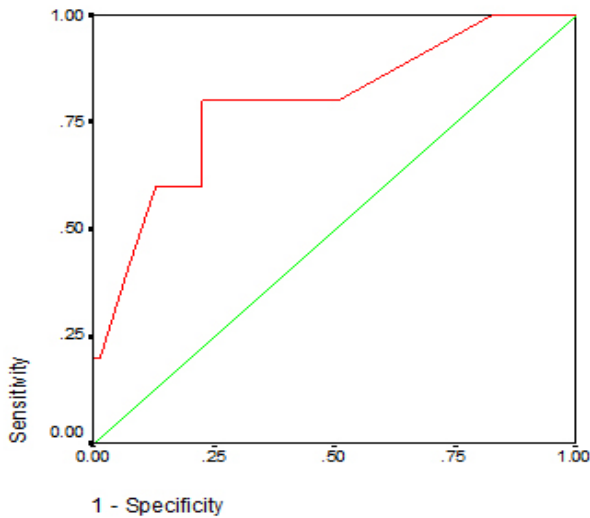


Figure 3. ROC curve for EuroSCORE

However, ROC curve analysis for the EuroSCORE showed statistically significant value compared to the Parsonnet score. Also, the EuroSCORE has a higher specificity than Parsonnet score. This is an indication that EuroSCORE algorithm is more capable for discrimination between patients who survived and those who died (Table 2).

Hospital Mortality:

Overall observed hospital mortality was 5/90 patients (5.55%). Mean score for alive and dead patients for EuroSCORE was

4.2 ± 2 and 7.4 ± 3.8; and for Parsonnet score 9.5 ± 7; and 14.8 ± 10.4, respectively.

In Parsonnet model, predicted mortality was, 2.6% for 5-9% risk, 5.15% for 10-14% risk, 5.85% for 15-19% risk, 18.7%

for 20% plus risk, and 4.26% for overall patients. Observed mortality was 3.03, 7.14, 20, 20, and 5.55%, respectively.

Table 2. ROC curve validity of Parsonnet score and EuroSCORE

Measurements	Parsonnet score	EuroSCORE
Area	0.715	0.794
Significance	0.107	0.028
Cut off point	2.75	4.57
Sensitivity	80.0%	80.0%
Specificity	52.0%	77.6%

In the EuroSCORE model, predicted mortality was 1.5% for 0-2 risk, 2.9% for 3-5 risk, 9.16% for 6-8 risk, 65.2% for 12 plus risk, and 4.5% for overall patients. Actual mortality was 0, 3.7, 9.5, 100 and 5.55%, respectively.

Comparison of the overall observed mortality and the overall predicted mortality calculated by both scores showed non significant difference (Table 3). This indicates a satisfactory practice for those patients undergoing mitral valve replacement

Table 3. Comparison of observed and expected mortality

Mortality	%	Z	p
Observed	5.6		
Estimated by Parsonnet score	4.3	0.098	0.922
Estimated by EuroSCORE	4.5	0.032	0.974

DISCUSSION

Quality monitoring is now one of the requirements of good surgical practice. Future debate in this field will focus on the measurement of this quality (9). In cardiac surgery, it has long been accepted that operative or hospital mortality is the most important indicator of quality of care (2).

It is almost intuitive that if outcomes are to be used as quality indicators, they must be adjusted for severity of patient illness, hence the need for a reliable risk stratification model (15).

Thus, one important goal of our study was to compare the selected risk scores with regard to their validity for our patient population undergoing MVR. To the best of our knowledge, the comparison between Parsonnet and EuroScore has not been done in Egyptian patients who had MVR. Also, there is no national risk score to compare with. The study was supposed to supply data which may assist in selecting an appropriate score.

Unfortunately, there have been few outcome prediction studies of valve surgery comparable to those of coronary surgery. Accordingly, the risk factors associated with valve surgery are more obscure, and acceptable outcomes are more

difficult to define. Risk models have only recently been used to evaluate patients undergoing valve replacement surgery (16-18).

Our hypothesis was to test both scoring system in a subset of patients undergoing open heart surgery, i.e. patients who had MVR. Restriction to mitral valve cohort of patients has a conceptual advantage over testing the score systems for a broad variety of surgeries. In this setting, the focus is on predictors that are specific or peculiar to that entity.

One important fact to remember is that no risk scoring system is perfect when applied to an individual patient, it only allows an educated estimate of risk.

Risk stratification, however, will inform patients and clinicians of the likely risk of death for a group of patients with a similar risk profile undergoing the proposed operation. This information is useful, and should form part of the basis on which the patient and surgeon decide whether to proceed (9).

In this study, with regard to mortality, both Parsonnet and EuroSCORE showed areas under the curve greater than 70% and qualified therefore as applicable models in patients undergoing MVR, as an area under the curve greater than 70% is usually considered to be associated with a good predictive value (12).

Analysis of ROC curves yielded results for areas under the curve which are in fairly good agreement with those reported in the literature (19,20).

Among the investigated scores, the Euro score yielded the highest predictive value (greatest area under the ROC curve 0.794) in our patient population.

Also, in our experience, the EuroSCORE performs very well, with higher specificity than Parsonnet score, and it seems to be a more appropriate tool for risk assessment in patients undergoing MVR.

Some reservations have been expressed previously about the Parsonnet score, including suggestions that its ability to predict mortality is only moderate, that it is more suitable for coronary surgery cohort, that some of the risk factors are subjective, and that many of the items included in the score are not significantly associated with mortality (12,21). However, the score has strengths in that it is widely accepted by the cardiac surgical community and it is easy to use.

On the other hand, it could be argued that the EuroSCORE is objective and resistant to manipulation. Most Euro-SCORE risk factors are derived from the clinical status of the patient. Only four risk factors are related to the operation and these are factors that are difficult to influence through subtle variation in surgical decision-making. EuroSCORE has been tested against a large database; such a system should provide very accurate risk assessment for small subgroups of patients (9).

Also, EuroSCORE has been developed to predict mortality for both CABG and valve replacement patients (9,15).

In our study, the observed hospital mortality was 5.55% which seems to be higher than predicted by Parsonnet score (4.26%) and by EuroSCORE (4.5%). Of note, statistical analysis failed to show significant difference between observed and predicted mortality assuring sound surgical performance.

It is worth to mention that about 45% of our patients are a high risk group with severe pulmonary hypertension (mean systolic pressure 76.1 ± 17.3). The incidence of mortality in those patients was (4/41) 9.75% compared to (1/49) 2.04% in patients without severe pulmonary hypertension. Without risk stratification, surgeons and hospitals treating high-risk patients will appear to have worse results than others. This may prejudice referral patterns, affect the allocation of resources and even discourage the treatment of high-risk patients. This is especially undesirable in cardiac surgery because it is precisely this group of patients which stands to gain most from surgical treatment, in spite of the increased risk (22). Risk stratification helps eliminate the bias against high-risk patients (23).

A prognostic system that establishes a predicted mortality rate for each unit based on a representative database and a patient-by-patient measurement of risk allows comparison of observed versus predicted outcomes. The difference between actual and predicted death rates provides an outcome-based measure of quality of care and provides insight into means for improving performance.

Limitations of the Study:

Although differences between scores for areas under the ROC curve were statistically significant, it is important to note that the selected score systems in this study give no information on the minimally required sample size for accurate predictions. Therefore, statistical comparisons based on larger patient numbers might come to different results. There is a need for further studies on a larger scale, to clarify potential errors in datasets such as this, and to see how such errors can influence the results of this type of analysis.

The data base for the initial Parsonnet score is now older than 15 years, and it seems likely that its predictive value was lessened by advances in surgical and medical therapy achieved during this period of time. As this process would apply to any score system over time, revalidation of score items at regular intervals seems warranted.

It may be that omitting various subjective risk factors from or adding more risk factors that proved to be related to mortality over recent years to the predictive models will be necessary to solidify the results and eliminate the potential for gaming.

Clearly, no 'perfect' model can be produced as some aspects of mortality will always be related to risk factors not included in the model or due to chance happenings not related to

preoperative patient characteristics (such as surgical error).

CONCLUSIONS

The EuroSCORE is more reasonable overall predictor of hospital mortality in our patients undergoing MVR compared to Parsonnet score. It can serve as a baseline for the development of a local risk model. However, there is a need for further validation studies on a larger scale than we have performed to obtain robust conclusions.

It is imperative to understand the validity of the predictive model, but of paramount importance is the way these models can be integrated into programmes to determine and improve standards of acceptable practice.

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