Biomedical and psychological risk in cardiac surgery: is EuroSCORE a more comprehensive risk measure than Stroke Index?*†

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Objective: Several composite risk score indices, the most common being the Stroke Index and the European System for Cardiac Operative Risk Evaluation (EuroSCORE), have been developed to predict perioperative events such as cerebrovascular accidents or death. The main aim of the present study was to compare the preoperative associations between the Stroke Index or the EuroSCORE with anxiety, depression, memory, attention, and executive functions scores in patients undergoing cardiac surgery. Methods: Ninety-one patients were required to perform a preoperative psychological evaluation. Trail Making Test A and B (TMT A/B), Memory with 10 and 30 s interference, Digit Span Test, Phonemic Fluency, State and Trait Anxiety Inventory (STAI Y1/Y2), and Center for Epidemiological Study of Depression Scale (CES-D) were administered. The Stroke Index and the EuroSCORE were also considered for each patient. Correlations between the Stroke Index or the EuroSCORE, mood, and neuropsychological scores were performed. Results: Seventy-seven patients completed the psychological evaluation. The Stroke Index was significantly correlated with TMT A ($\rho = 0.40$, $p = 0.001$), TMT B ($\rho = 0.38$, $p = 0.001$), Memory with 10 s ($\rho = -0.34$, $p = 0.003$) and 30 s ($\rho = -0.40$, $p = 0.001$) interference, and Phonemic Fluency ($\rho = -0.29$, $p = 0.01$), but not with Digit Span Test ($\rho = -0.18$, $p = 0.13$), STAI Y1 ($\rho = 0.08$, $p = 0.44$), STAI Y2 ($\rho = 0.06$, $p = 0.56$), and CES-D ($\rho = 0.11$, $p = 0.31$) scores. The EuroSCORE was significantly correlated not only with TMT A ($\rho = 0.49$, $p = 0.001$), TMT B ($\rho = 0.42$, $p = 0.001$), Memory with 10 s ($\rho = -0.23$, $p = 0.04$) and 30 s ($\rho = -0.35$, $p = 0.002$) interference, Phonemic Fluency ($\rho = -0.28$, $p = 0.01$), and Digit Span Test ($\rho = -0.28$, $p = 0.01$) but also with STAI Y1 ($\rho = 0.27$, $p = 0.02$), STAI Y2 ($\rho = 0.23$, $p = 0.04$), and CES-D ($\rho = 0.26$, $p = 0.02$). Conclusions: While both the Stroke Index and the EuroSCORE account for the relationship between biomedical and cognitive risk factors in predicting perioperative risk, only the EuroSCORE also accounts for affective dysfunctions, which, in turn, have been proved to represent risk factors for perioperative adverse events. Therefore, compared with the Stroke Index, the EuroSCORE can be considered a more complete risk index in predicting perioperative risk. Data also suggest that a comprehensive preoperative evaluation of biomedical, mood, and cognitive performances might provide a more accurate mirror of the actual risk in patients undergoing cardiac surgery.

Keywords: Cardiac surgery; Risk scores; Risk factors; Neuropsychology; Anxiety; Depression

1. Introduction

Several demographic (e.g., age or sex) or biomedical (e.g., diabetes, unstable angina, or left-ventricular (LV) dysfunction) factors are relevant risk factors in patients undergoing cardiac surgery. Based upon this evidence, several research groups have proposed composite risk scores able to predict perioperative adverse events in cardiac surgery. Among the risk indices, the Stroke Index (SI) [1] and the logistic European System for Cardiac Operative Risk Evaluation (EuroSCORE) [2] are the most used as relevant predictors of perioperative cerebrovascular accident (CVA) or mortality. EuroSCORE has been also used to develop a risk stratification system, especially for high-risk patients undergoing cardiac surgery [3]. Both risk indices comprise demographic and biomedical variables: age, diabetes, unstable angina, previous heart surgery, history of vascular, neurological, and/or pulmonary disease are included in the SI [1]; patient-related factors (i.e., age, sex, chronic pulmonary disease, extracardiac arteriopathy, neurological dysfunction, previous cardiac
surgery, serum creatinine, and active endocarditis), cardiac-related factors (i.e., unstable angina, LV dysfunction, recent myocardial infarct, and pulmonary hypertension) and operation-related factors (i.e., emergency operation, other than isolated coronary artery bypass graft, thoracic aortic surgery, critical preoperative state, and ventricular septal rupture) are included in the EuroSCORE [2,4].

Most of the above-mentioned demographic and biometrical variables have been independently associated with cognitive functioning such as memory, attention, and language performances [5–9]. Moreover, mood disorders such as anxiety and depression have also shown relationships with most of the SI and the EuroSCORE variables [6,10,11]. Preoperative mood and cognitive performances are also relevant predictors for early postoperative psychological dysfunctions, which, in turn, are associated with a prolonged hospitalization and mortality after cardiac surgery [12–15].

In spite of the relationships between mood, cognitive performances, and most of biomedical risk variables, only one single study assessed the associations between the global SI risk scores and psychological functioning. The authors indicated a significant relationship between the global SI score and cognitive performances but not with anxiety and depression. It is still unknown whether the two measures (SI and EuroSCORE) or one better than the other can differently account for psychological risk associated with demographic and biomedical risk factors. Therefore, the main aim of the present study was to compare the preoperative SI and EuroSCORE associations with anxiety, depression, and neuropsychological scores in patients undergoing cardiac surgery.

2. Materials and methods

2.1. Enrollment of patients

Following local ethic committee’s approval, 91 patients were required to give written informed consent and were recruited into the study. Incapability to read or understand Italian language, visual or auditory impairments and use of psychotropic were the exclusion criteria. Fourteen patients, who failed to complete the psychological evaluation, were excluded from the statistical analysis. Patients included in the analysis (N = 77) were prevalently males (65%) with a mean age of 64.5 ± 10.7 years (range from 27 to 82 years) and a mean education of 8.4 ± 4.3 years, as reported in Table 1.

2.2. Risk scores and psychological evaluation

The SI score was calculated for each patient according to the criteria reported by Newman and colleagues [1]. Risk score was computed as follows: age ((age – 25) × 1.43), history of symptomatic neurological diseases (18 points), diabetes (17 points), history of vascular diseases (18 points), unstable angina (14 points), prior heart surgery (16 points), and history of pulmonary diseases (15 points). Higher SI scores represent a higher risk of CVA during cardiac surgery.

EuroSCORE was determined for each patient using the logistic regression model of EuroSCORE [4], based on the following variables: age, sex, chronic pulmonary disease, extracardiac arteriopathy, neurological dysfunction, previous cardiac surgery, serum creatinine, active endocarditis, unstable angina, LV dysfunction, recent myocardial infarct, pulmonary hypertension, emergency operation, other than isolated coronary artery bypass graft (CABG), thoracic aortic surgery, critical preoperative state, and ventricular septal rupture. The logistic EuroSCORE was calculated as indicated by Roques and colleagues [4]. Higher EuroSCORE values predict a higher risk of mortality due to cardiac surgery.

The psychological evaluation included self-report questionnaires and tests aimed at assessing anxiety, depression and cognitive performances such as memory, attention and executive functions. All self-report questionnaires and tests were preoperatively administered individually by a trained psychologist blind to the patient’s SI and EuroSCORE values. The anxiety and depression questionnaires consisted of:

(1) State-Trait Anxiety Inventory (STAI Y1—Y2) [16], which is composed by two 20-items scales that measure state or trait anxiety, respectively. State anxiety represents the subject’s current and transitory anxiety, whereas trait anxiety indicates a long-lasting and persistent anxiety.

### Table 1. Characteristics of patients enrolled in the study.

<table>
<thead>
<tr>
<th>Variable included in the analysis N = 77</th>
<th>Not included in the analysis N = 14</th>
<th>( p^* )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex, male (%)</td>
<td>65</td>
<td>50</td>
</tr>
<tr>
<td>Mean (SD) age</td>
<td>64.5 (±10.7)</td>
<td>72.2 (±7.1)</td>
</tr>
<tr>
<td>Mean (SD) education</td>
<td>8.4 (±4.3)</td>
<td>5.6 (±2.2)</td>
</tr>
<tr>
<td>Mean (SD) body mass index (kg/m²)</td>
<td>27.8 (±4.8)</td>
<td>26 (±5.1)</td>
</tr>
</tbody>
</table>

SD: standard deviation; bpm: beats per minute.

* Statistical unpaired t-test.
* Statistical \( \chi^2 \)-test.
* Fisher’s exact test.
* \( p \)-value.
Indeed, test–retest reliability with a 1-month interval is very high for STAI Y2 (r = 0.82), which evaluates the stable trait of anxiety, while it is moderate for STAI Y1 (r = 0.49), which, in turn, investigates time-dependent or fluctuant anxiety [16]. The scores range between 20 and 80 for both scales, with higher scores representing higher anxiety.

(2) Center for Epidemiological Studies Depression Scale (CES-D) [17], which consists of 20 items representing the more common symptoms of depression. The scores range from 0 to 60, with higher scores indicating higher depressive symptoms. Although the CES-D scale was designed to be sensitive to possible depressive reactions to events in a person’s life, the test–retest reliability of CES-D is adequate (r = 0.54); it provides the evidence that CES-D scores are similar across time and across a wide variety of demographic characteristics in the general population [17].

The neuropsychological battery included:

(1) Trail Making Test A and B parts (TMT A and B) [18]. As recommended by the Consensus on Neurobehavorial Assessment [19], it requires subjects to connect numbered circles drawing lines with a pencil (part A). Part B requires subjects to connect alternatively numbered and alphabetic circles. These tasks investigate executive functions such as attention, psychomotor speed and cognitive switching skills. Scores are expressed in seconds for tests’ completion. Higher scores indicate worse performances.

(2) Memory with interference 10/30 s [20]. This is a dual-task test. Subjects have to remember a sequence of three consonants, while they are counting two by two for either 10 or 30 s. These tests evaluate working memory skills during an interference task. Scores range from 0 to 9: higher scores represent a better performance.

(3) Digit Span Test [21]. The test is a short-term memory task, it consists of a growing series of numbers that the examiner reads aloud. Subjects are required to remember and repeat them orally. Scores range from 2 to 8 and higher scores indicate a better short-term memory span.

(4) Phonemic Verbal Fluency Test [22]. This investigates lexical access and frontal strategic search processes. Subjects must name words beginning with a given particular consonant. Scores are calculated as number of words. Higher scores represent better performances.

2.3. Statistical analysis

χ² test or Fisher’s exact test for categorical and unpaired t-test for continuous variables were performed to estimate whether preoperative medical and demographic characteristics of patients included in the statistical analysis were similar to those who were not.

SI, EuroSCORE, anxiety, depression, and neuropsychological scores were calculated for each patient. Statistical correlations were calculated between SI or EuroSCORE, anxiety, depression, and neuropsychological scores. All statistical correlations were conducted using non-parametric Spearman’s correlation coefficient.

A p-value of <0.05 was considered statistically significant. STATISTICA 6.1 software was used for each statistical analysis.

3. Results

Significant differences were observed between included and not-included groups in age, education and EuroSCORE (Table 1).

Significant correlations were found between SI and TMT A (ρ = 0.40, p = 0.001), TMT B (ρ = 0.38, p = 0.001), Memory with 10 (ρ = −0.34, p = 0.003) and 30 s (ρ = −0.40, p = 0.001) interference, and Phonemic Fluency (ρ = −0.29, p = 0.01). SI failed to show any significant associations with Digit Span Test (ρ = −0.18, p = 0.13), STAI Y1 (ρ = 0.08, p = 0.44), STAI Y2 (ρ = 0.06, p = 0.56), and CES-D (ρ = 0.11, p = 0.31) scores. EuroSCORE showed significant correlations with TMT A (ρ = 0.49, p = 0.001), TMT B (ρ = 0.42, p = 0.001), Memory with 10 s (ρ = −0.23, p = 0.04) and 30 s (ρ = −0.35, p = 0.002) interference, Phonemic Fluency (ρ = −0.28, p = 0.01), and Digit Span Test (ρ = −0.28, p = 0.01), and also with STAI Y1 (ρ = 0.27, p = 0.02), STAI Y2 (ρ = 0.23, p = 0.04), and CES-D (ρ = 0.26, p = 0.02). Correlations are reported in Table 2; correlations between both risk indices and affective variables are reported in Fig. 1.

Table 2. Spearman’s correlations between SI or EuroSCORE and anxiety, depression and neuropsychological scores.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Stoke Index</th>
<th></th>
<th></th>
<th>EuroSCORE</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ρ</td>
<td>p *</td>
<td>ρ</td>
<td>p *</td>
<td>ρ</td>
<td>p *</td>
</tr>
<tr>
<td>Trail Making Test A b</td>
<td>0.40</td>
<td>0.001</td>
<td>0.49</td>
<td>0.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trail Making Test B b</td>
<td>0.38</td>
<td>0.001</td>
<td>0.42</td>
<td>0.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Memory with 10 s interference a</td>
<td>−0.34</td>
<td>0.003</td>
<td>−0.23</td>
<td>0.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Memory with 30 s interference a</td>
<td>−0.40</td>
<td>0.001</td>
<td>−0.35</td>
<td>0.002</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phonemic Fluency a</td>
<td>−0.29</td>
<td>0.01</td>
<td>−0.28</td>
<td>0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digit Span Test (forward) b</td>
<td>−0.18</td>
<td>0.13</td>
<td>−0.28</td>
<td>0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>State-Trait Anxiety Inventory Y1 b</td>
<td>0.08</td>
<td>0.44</td>
<td>0.27</td>
<td>0.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>State-Trait Anxiety Inventory Y2 b</td>
<td>0.06</td>
<td>0.36</td>
<td>0.23</td>
<td>0.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Center for epidemiological study depression scale b</td>
<td>0.11</td>
<td>0.31</td>
<td>0.26</td>
<td>0.02</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Higher scores indicate better functions.

b Higher scores indicate worse functions.

p-value.
4. Discussion

Many risk factors such as age, diabetes, unstable angina and LV dysfunction comprised in the SI and EuroSCORE have been previously associated with anxiety [6,10,11], depression and neuropsychological deficits, especially memory, attention and executive functions [5—9]. In line with previous literature, the SI and EuroSCORE showed significant correlations with neuropsychological performances: indeed, higher SI and EuroSCORE were associated with worse memory, attention and executive functions. EuroSCORE, but not SI, was correlated to short-term memory span (Digit Span Test). Therefore, although both the SI and the EuroSCORE account for several potential risk factors influenced by neuropsychological deficits in patients undergoing cardiac surgery, the EuroSCORE seems to provide a more accurate measure also in relation with memory dysfunction, which, in turn, can be easily worsened by intra-operative events such as embolization load, hypoperfusion, and neuroinflammatory processes, mostly related to cardiopulmonary bypass technique.

The present study also aimed at measuring the correlations between the SI, the EuroSCORE, and affective variables. Most of the SI and the EuroSCORE variables have been related with anxiety and depression [6,10,11], which are significant risk factors for subsequent cardiac events and mortality [12,14,15] in cardiac surgery patients. The present results indicated that the EuroSCORE, but not the SI, was significantly correlated with anxiety and depression scores. Although the correlations between the EuroSCORE and mood were moderate, the EuroSCORE, but not the SI, might account for the potential risk factors associated with state and trait anxiety and depression as measured with STAI Y1, STAI Y2 and CES-D, respectively. Based on these data, the SI score might underestimate the perioperative risk of patients undergoing cardiac surgery, whereas the EuroSCORE might also account for risk factors due to preoperative anxiety and depressive symptoms. In addition, the EuroSCORE seems to represent a useful index to evaluate the association between biomedical risk factors and the state anxiety, which, in turn, might affect the cognitive performance in patients undergoing cardiac surgery.

It is noteworthy that the EuroSCORE predicts the overall risk of mortality in which the risk of stroke measured by SI might be included. Therefore, while the EuroSCORE might comprehend a global evaluation of patients undergoing cardiac surgery, the SI might be considered an index able to specifically predict only stroke risk and cognitive functioning.

Comparison between included and excluded patients showed that, in line with previous literature, the patients who were not able to complete the psychological evaluation were older, with lower education and with higher EuroSCORE. These findings indirectly strengthen the evidence of the association between variables related with cardiac surgery risk as measured by the EuroSCORE (i.e., patient-, cardiac-, and operation-related factors) and preoperative cognitive reserve of patients undergoing cardiac surgery. Thus, they also suggest the need for an appropriate psychological evaluation, possibly using age- and education-related tests, providing further useful information concerning the preoperative psychological functioning of cardiac surgery patients. Again, compared with the SI, the EuroSCORE represents a more suitable risk score able to detect the cognitive impairments and mood dysfunctions of high-risk patients undergoing cardiac surgery.

Further studies should investigate the additive contribution of each variable to the SI and EuroSCORE preoperative risk scores and their potential predicting values on post-operative dysfunctions. The associations between the EuroSCORE and SI scores with state and trait anxiety and depression as measured with other well-validated questionnaires (e.g., Beck Anxiety Inventory, Beck Depression Inventory, and Depression Anxiety Stress Scale), should also be taken into account. Moreover, it should be investigated whether each variable included in the SI or EuroSCORE (e.g., age, neurological disease, and previous heart surgery), taken separately, might be associated with preoperative cognitive performances, anxiety or depression in cardiac surgery patients.

In conclusion, our data suggest that the EuroSCORE might provide a more complete risk score compared with the SI for patients undergoing cardiac surgery. Thus, the EuroSCORE is recommended as it represents a more accurate mirror of the patients’ psychological status compared with the SI. Moreover, a preoperative age- and education-related psychological assessment is to be taken into account to evaluate the cognitive functioning, anxiety and depression in patients undergoing cardiac surgery.

Acknowledgments

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References


