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Relationship between Perioperative Risk and Cardio-Respiratory Fitness after Coronary Artery Bypass Grafting

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Original Article

Relationship Between Perioperative Risk and Cardio-Respiratory Fitness After Coronary Artery Bypass Grafting

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Introduction and objectives: The European System for Cardiac Operative Risk Evaluation II (euroSCORE II) is a validated model for predicting perioperative mortality after cardiac surgery. The role of cardio-respiratory fitness (CRF), expressed as peak metabolic equivalents (METs), as a predictor of long-term survival in patients who have previously undergone coronary artery bypass grafting (CABG) is well established. However, the correlation between perioperative risk and CRF has not been evaluated.The aim of this study was to investigate the relationship between perioperative risk and CRF in patients after CABG.

Methods: Patients who underwent CABG from January 2012 through December 2013 at VGH-TPE were queried, and those who completed cardiopulmonary exercise testing (CPET) around four weeks after discharge from the hospital were enrolled. Electronic medical records were reviewed to calculate euroSCORE II. Peak METs established by treadmill was used to measure CRF.

Results: Twenty-nine patients (25 males+4 females) were included. The mean peak MET was 4.92±1.34, and the mean perioperative risk of mortality measured by euroSCORE II was 1.52±0.96%. An inverse correlation between peak MET and perioperative risk was identified (Spearman’s correlation p=-0.508, p=0.005)

Conclusions: The present study provides information not previously found in the literature that euroSCORE II is correlated with CRF in patients after CABG. For those with a higher euroSCORE II, aggressive phase I and phase II cardiac rehabilitation are indicated. Further studies to justify the use of euroSCORE II as an indicator of CRF in other disease categories are warranted. (Tw J Phys Med Rehabil 2015; 43(2): 83 - 89)

Key Words: Perioperative risk, Cardio-respiratory fitness, Cardiopulmonary exercise testing (CPET), Coronary artery bypass grafting (CABG), The European System for Cardiac Operative Risk Evaluation II (euroSCORE II)

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INTRODUCTION

A low level of cardiorespiratory fitness (CRF) is known as one of the strongest and most consistent marker for poor prognosis in cardiovascular disease and all-cause mortality.[1,2] Furthermore, low CRF acts as an independent marker for mortality after coronary artery bypass grafting (CABG)[3].

The “gold standard” measure of CRF is peak oxygen uptake (VO_{2peak}), expressed as milliliters of O_2 uptake • kilograms of body mass^{-1} • minutes^{-1} (ml/kg/min), or metabolic equivalents (METs); 1 MET equals 3.5 ml O_2/kg/min. VO_{2max} can be assessed with direct or indirect procedures.[4,5] However, both methods may be impractical for clinical use and the decision to measure CRF is often influenced by the feasibility and cost. Several non-exercise measures for CRF were suggested in the literature,[6,7] but these measures tended to include self-reported physical activity as a variable, which was graded based on the patients' subjective judgment. Furthermore, instead of using cardiac patients, these measures were only validated with healthy subjects. Whether or not it is applicable to cardiac patients was unclear.

The European System for Cardiac Operative Risk Evaluation (euroSCORE) is a multivariate model, published in 1999, designed to predict the risk of perioperative mortality in patients receiving cardiac surgery.[8] Furthermore, euroSCORE evolved from merely a perioperative risk prediction model to long-term mortality and quality of life prediction model.[9,10] After 12 years of use, the model was modified due to improved surgical techniques and postoperative care. The euroSCORE design group has incorporated new data into a second-generation model named “euroSCORE II”[11] The excellent overall performance of euroSCORE II was recently validated in a meta-analysis of 22 studies involving 145,592 patients. [12]

Whether perioperative risk correlates with post-operative CRF is unknown. In the present study, we sought to evaluate the relationship between perioperative risk and post-operative CRF in patients receiving CABG surgery.

METHODS

Study population

For this retrospective, single-center (Taipei Veterans General Hospital, Taiwan) study, we recruited patients who underwent CABG from January 2012 through December 2013, and enrolled those who completed cardiopulmonary exercise testing (CPET) around four weeks (4.05 ± 0.58 week) after discharge from the hospital. Patients who received CABG combined with other surgeries such as valve surgery or atrial ablative surgery were excluded.

Electronic medical records were reviewed for the data needed to calculate euroSCORE II using the on-line calculator (http://www.euroscore.org/calc.html). The factors included three domains:

Patient-related factors: age, gender, renal impairment, extracardiac arteriopathy, poor mobility, previous cardiac surgery, chronic lung disease, active endocarditis, critical preoperative state, and diabetes on insulin.

Cardiac-related factors: New York Heart Association (NYHA), Canadian Cardiovascular Society (CCS) class 4 angina, Left Ventricle(LV) function, recent myocardial infarction, and pulmonary hypertension.

Operation-related factors: urgency, weight of intervention, surgery on the thoracic aorta. All factors were classified and graded according to the definition of the euroSCORE design group. [11]

Cardiopulmonary exercise testing (CPET)

CPET was performed using a ramping treadmill protocol, and the pulmonary function test was performed with the V max pulmonary function analyzer (Carefusion, San Diego, CA, USA). The CPET was terminated according to absolute and relative termination indications.[13] Aerobic threshold was identified using V-slope analysis.[14,15] Functional aerobic impairment (%FAI) was calculated as follows[16]:

$$\%FAI = \frac{\text{predicted maximal oxygen uptake} - \text{observed maximal oxygen uptake}}{\text{Predicted maximal oxygen uptake}} \times 10^2$$

Statistical analysis

Statistical analysis was performed using SPSS version 18.0 software (SPSS Inc., Chicago, IL, USA). Descriptive statistics were used to establish patient characteristics, and continuous data were expressed as mean ± standard deviation.

Spearman's rank correlation coefficient analysis was used to assess the associations between the variables. Spearman's rank correlation coefficient values were categorized as follows: very weak correlation (0 to 0.19), weak correlation (0.2 to 0.39), moderate (0.4 to 0.59), strong (0.6-0.79), and very strong correlation (0.8 to 1.0). A p value < 0.05 was considered statistically significant.

RESULTS

Twenty-nine patients were enrolled into this retrospective study. The study sample had a mean age of 64.23 ±11.29 years (25 men, 4 women). The mean peak MET was 4.92 ± 1.34, and the mean perioperative risk of mortality measured by EuroSCORE II was 1.52% (Table 1).

CRF ranged from 3.1 to 8.9 METs, with most patients attaining ≧ 5 METs (Figure 1).

We showed an inverse correlation between peak VO_2 and euroSCORE II. Spearman's rank correlation coefficient demonstrated a moderate degree (p=-0.508) of inverse association between peak VO_2 and euroSCORE II ($p = 0.005$) (Figure 2).

Table 1. Background characteristics of subjects.

	Total	Male	Female
Case number	29	25	4
Mean age (year)	64.23±11.29	64.04±10.74	63.25±16.82
METs	4.92±1.34	5.07±1.34	4.43±1.23
% of predicted peak VO2	69.83±19.8	70.56±18.65	65.25±29.09
Functional Aerobic Impaiment (FAI) (%)	30.17±19.8	29.44±18.65	34.75±29.09
Euroscore II	1.52±0.96	1.38±0.75	2.38±1.73

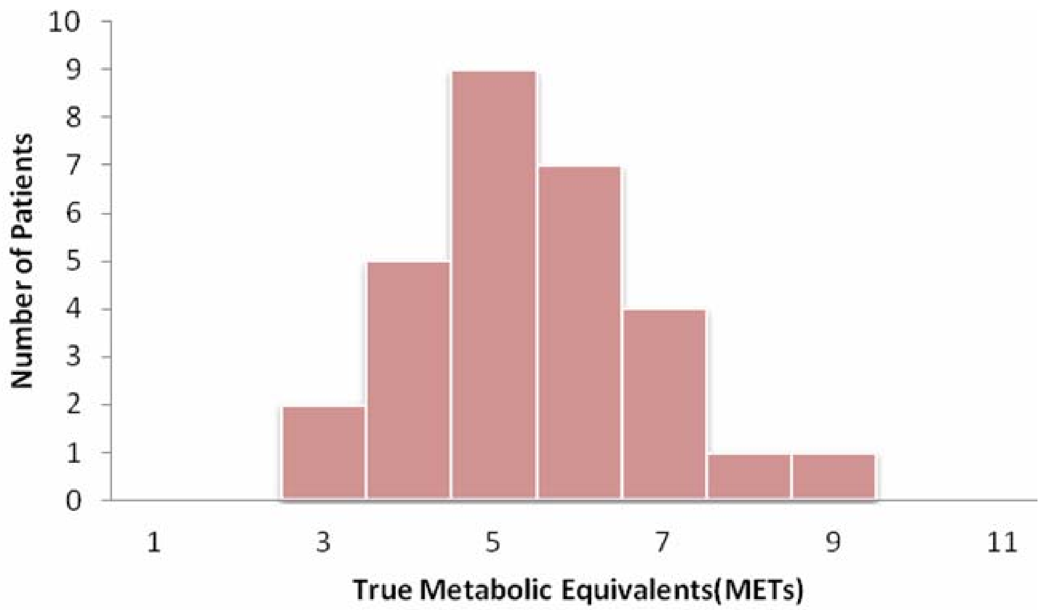

Figure 1. Cardiorespiratory Fitness in Patients that Underwent CABG
CRF ranged from 3.1 to 8.9 METs, with most patients attaining ≧ 5 METs

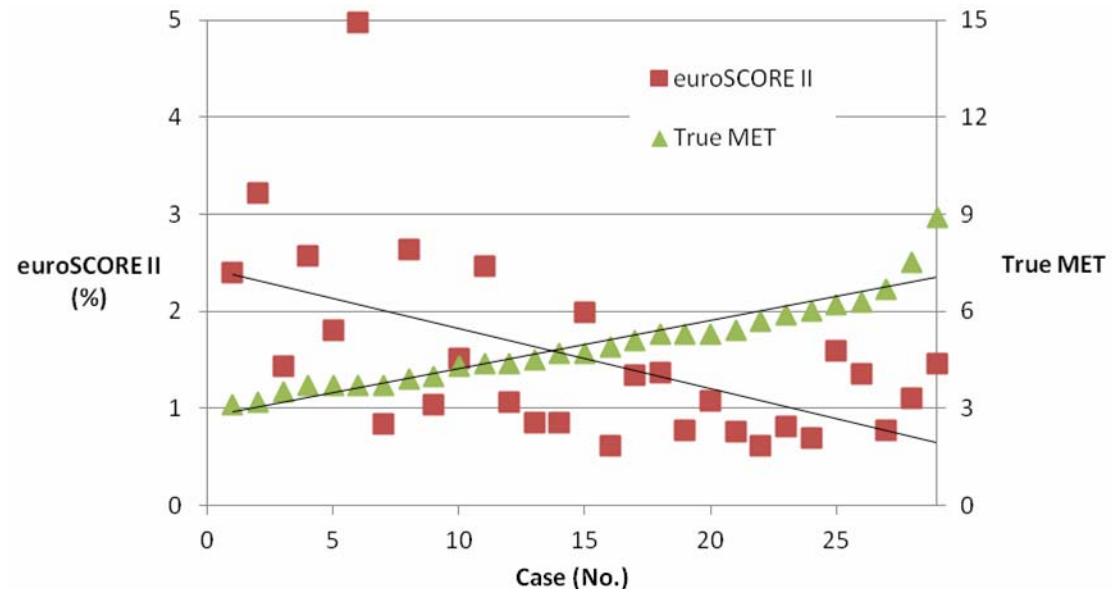

Figure 2. Relationship Between EuroSCORE II and peak metabolic equivalent (MET)
Spearman's rank correlation coefficient demonstrated a moderate degree (p=-0.508) of inverse association between peak metabolic equivalent and euroSCORE II (p = 0.005)

DISCUSSION

We found an inverse relationship between CRF, expressed as peak MET, and predicted perioperative risk, expressed as euroSCORE II. The baseline characteristics of our study population revealed that those with a lower euroSCORE II tended to have a higher exercise capacity. The oldest patient in the current study was 83, within the range of the euroSCORE II database, which was composed of 145,592 patients across 43 countries, mainly aged below 90.[11]

The distribution of patient numbers based on peak METs (Figure 1) was similar to that in a large-scale study by Hung et al[17] with higher mean METs. In their study subgroup of previous CABG, 2590 patients (mean age of 64±11 years), composed of 77% white people, 18% of black people, and 5% of other races, had a mean MET of 6.6±3, which was higher than in our current study. Considering current study subjects were all Asians, this difference might be explained by racial disparity. Caucasians were reported to have a significantly higher VO2max (10.9 METs vs. 8.0 METs) compared with age- and sex-matched African-Americans.[18] However, there was no epidemiology study comparing differences between Caucasian, African-American, and Taiwanese. Besides, we found a relatively low participation rate in phase II cardiac rehabilitation for cardiac patients in our hospital. Those with exercise capacity adequate for daily activities tended not to join the rehabilitation program. The participation rate in phase II cardiac rehabilitation was reported to be 52.5% in a population study in Olmsted County, Minnesota[19], but only 20% of patients returned for phase II cardiac rehabilitation in our previous study.[20]

CRF is a strong independent predictor of all-cause mortality and a more accurate measure for general fitness than self-reported physical activity.[21] In current daily practice, the cost and feasibility issues involved in measuring CRF make it difficult to include into the routine practice, whether using direct or indirect methods. Hence, the poor accessibility of measuring CRF became the main obstacle to participate in cardiac rehabilitation, leading to a low participation rate.[22] To resolve the problem, Jurca R., et al.[6] and Sloan RA., et al.[7] used age, body mass index, resting heart rate, and physical activity score to predict CRF. However, the lack of an objective definition of the physical activity score and using a database of apparently healthy subjects are major obstacles to applying the prediction model with cardiac patients.

The original euroSCORE model, whether the additive or logistic regression model, was designed to predict 30-day post-operative mortality in the beginning.[23] Loponen P and colleagues extended its use to predict long-term mortality and quality of life.[24] The modified euroSCORE II, derived from the latest data, is believed to be better calibrated, and should better reflect current practice.

Information on the relationship between perioperative risk and post-oprative CRF are scarce. In a prospective study of 145 patients,[25] exercise capacity after valvular surgery was related to perioperative risk (euroSCORE) and the type of surgery.

The current study extends the usage of the euroSCORE II beyond mortality prediction. Our findings indicate that patients who had a higher perioperative risk also had worse CRF after surgery. In current practice, cardiac rehabilitation has been shown to improve survival and morbidity following CABG in longitudinal studies,[26] and early postoperative cardiac rehabilitation significantly improved physical capacity and quality of life among patients with CABG,[27] exercise training is recommended, especially for those with a higher perioperative risk.

LIMITATION

There are several significant limitations to our study methods. First, the study was retrospective in design, with a small sample size at one single medical center. Second, our patient population was recruited based on physician-referral, resulting in a potential selection bias; therefore, our results cannot be widely applied to all patients with CABG surgery. Third, our patient group was male-predominant, and application of our results to female patients needs further investigation.

CONCLUSION

A prediction model, if designed and calibrated well, could be used to guide decision making. EuroSCORE II is one of several available tools, and it is the most recent risk assessment system validated with extensive clinical variables using an international database. Our study found an inverse relationship between euroSCORE II and CRF in cardiac patients receiving CABG. Aggressive phase I and phase II cardiac rehabilitations are recommended for those patients with higher euroSCORE II. Further study with larger case numbers and the inclusion of different cardiac surgeries is needed to investigate the possibility of using the euroSCORE II as a non-exercise surrogate for CRF measurement in cardiac patients.

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冠狀動脈繞道手術病人手術風險與心肺適能之相關性研究

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前言：European System for Cardiac Operative Risk Evaluation II (EuroSCORE II)是一個用來評估心臟手術術後三十天死亡率的預測模型，它的信效度已在許多研究中獲得證實。在接受冠狀動脈繞道手術的病人中，心肺適能 Cardio-respiratory fitness (CRF)已被證實爲一個長期存活率的預測因子。然而，接受心臟手術的風險和心肺適能間的關係卻未被研究討論。本實驗目的研究在冠狀動脈手術病人接受心臟手術的風險和心肺適能間的關係。

研究方法：這是一個回溯性研究，透過收集在 2012 年 1 月到 2013 年 12 月間於台北榮民總醫院接受冠狀動脈繞道手術的病人資料，我們找出曾在出院後四週內完成運動心肺功能測試的病人。透過電子病歷收集術前資料，換算出 EuroSCORE II 的分數，並以跑步機運動心肺功能測試結果的 MET 值來評估心肺適能。

研究結果：29 個病人被納入分析。其中有 25 位男性和 4 位女性。分析結果，平均 MET 值是 4.92±1.34，代表手術風險的 EuroSCORE II 平均值爲 1.52±0.96 %。以最大 MET 值代表的心肺適能和 EuroSCORE II 所代表的手術風險間呈中度負相關。(Spearman's correlation ρ=-0.508, p=0.005)

結論：本實驗發現在接受冠狀動脈繞道手術的病人中，接受手術的風險與心肺適能呈負相關。因此對 EuroSCORE II 較高的病人族群，術後應積極接受 phaseI 和 phaseII 的心肺復健。對於其他的心臟手術是否能用 EuroSCORE II 來評估心肺適能，尚待未來更進一步的研究。（台灣復健醫誌 2015；43(2)：83 - 89）

關鍵詞：手術風險(Perioperative risk)，心肺適能(Cardio-respiratory fittness)，心肺運動測試(Cardiopulmonary exercise testing, CPET)，冠狀動脈繞道手術(Coronary artery bypass grafting, CABG)，euro SCOREII 分數(The European System for Cardiac Operative Risk Evaluation II, euro SCORE II)

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