Pak Armed Forces Med J 2019; 69 (1): S64-S70

EFFECTIVENESS OF MAXIMUM FUNCTIONAL CAPACITY AS AN ASSESSMENT TOOL FOR PREOPERATIVE ASSESSMENT FOR CARDIAC SURGERY: AN INITIAL ANALYSIS

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ABSTRACT

Objective: To evaluate the value of VO2 max testing in the preoperative assessment of patients undergoing elective cardiac surgery. To investigate whether poor preoperative cardiopulmonary reserve and comorbid state dictate high risk status and predict complications in patients undergoing elective cardiac surgery.

Study Design: Descriptive cross sectional study.

Place and Duration of Study: AFIC/NIHD Rawalpindi Pakistan, from 2016 to 2017.

Material and Methods: Total number of 44 adult patients undergoing coronary artery bypass graft surgery (CABG) requiring cardiopulmonary bypass (CPB), having an EF of >45% were recruited in the study as per inclusion criteria through nonrandom consecutive sampling.

Results: We analyzed the data of 39 eligible patients (Male 35 (89.7%), Female 4 (10.3%)). Mean age of our study population was 55.0 ± 10.2 years and a mean BMI of 26.8 ± 3.81. There were 20 (54.1%) hypertensives, 2(5.4%) diabetics and 5 (13.5%) smokers. There was only one patient with a history of previous myocardial infarction (MI). Majority of the patients belonged to NYHA class II 30 (76.9%) with a mean EF of 56.6 ± 5.17. Prolonged ventilation (>24 hrs) was significantly associated with lesser values of VO2max with a *p*-value of 0.01.Similarly, post-operative prolonged BiPAP usage (>50hrs) was reported more in group I as compared to other groups. The incidence of postoperative pulmonary complications was significantly associated with lower values of VO2 max with a *p*-value=0.039.

Conclusion: We conclude from this study that VO2 max levels are correlated with postoperative outcome. Patients with cardiopulmonary fitness below the recommended cut-points are susceptible to postoperative complications and mortality.

Keywords: Cardiopulmonary exercise testing, Cardiac surgery, Peak oxygen uptake (VO2peak).

INTRODUCTION

The cardiac surgical patient group is progressively more aged and comorbid and show cases challenges to physicians and surgeons. Correct preoperative risk stratification is imperative to undeviating perioperative care. Post-operative morbidity and mortality are reduced aerobic fitness[1,2].

Cardiopulmonary exercise testing is an assimilated and vigorous assessment tool that gives an objective extent of functional capacity and aerobic fitness and recognizes the basis of exercise intolerance.Patient's risk of post-operative morbidity and mortality can be forecasted by cardiopulmonary exercise testing as it offers an individualized assessment of the patient's fitness for surgery [3,4]. This expertise can therefore be used to advise collective decision-making and patient accord, to triage the patient to a suitable perioperative care setting, to detect unexpected complications, to improve clinical comorbidities preoperatively, and to direct perso-nalized pre-operative exercise plans[5].

Functional capacity, estimated as the anaerobic threshold and peak oxygen uptake (VO2 peak) forecasts postoperative indisposition and mortality in the mainstream of surgical prospective studies. Surgical outcome in some cohort scan be predicted by The ventilatory parallels for

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carbon dioxide (an index of gas exchange efficiency). Prospective cohort studies are required to increase the precision of risk assessments for diverse patient groups and to elucidate the best grouping of variables to envisage outcome[6,7].Primary data advocates that preoperative exercise drill increases fitness, decreases the devastating effects of neoadjuvant chemotherapy, and may impactclinical outcomes positively. Added research is mandatory to ascertain the most effective category of training and the least time interval necessary for a positive outcome.

MATERIAL AND METHODS

Design and Patients

This observational, cross sectional, single-centre study was conducted at AFIC/NIHD from 2016-2017 and a total number of 44 adult patients undergoing coronary artery bypass graft surgery (CABG) requiring cardiopulmonary bypass (CPB), having an EF of >45% were recruited in the study as per inclusion criteria through nonrandom consecutive sampling. Emergency operations and patients with critical left main stem disease (LMSD), chronic obstructive pulmonary disease (COPD), musculoskeletal disorder, intermittent claudication, acute heart failure, unstable angina, valve replacement along with CABG surgery were excluded from the study. The patients according to inclusion criteria were divided into four groups.This study was carried out according to Good Clinical Practice guidelines and the Institutional ethical review board approved the study. All patients provided written informed consent before recruitment into the study.

Study Protocol

Patient data was recorded in our present surgery database registry, comprising of variables related to demographics, clinical history, preoperative, per operative and postoperative characteristics, presence of coexisting cardiovascular and medical conditions, medications at presentation and at discharge. Patients were characterized as having CAD if they have a history of chronic angina, a stress test positive for ischemia, a prior myocardial infarction, coronary stenosis >70%. Coronary artery on coronary angiogram, or prior coronary angioplasty or coronary bypass surgery. Cardiovascular or medical conditions that could precipitate hospitalization were recorded.

Operational Definitions

Max oxygen consumption(VO2) max refers to the maximum amount of oxygen that an individual can utilize during intense or maximal exercise. It is measured as "milliliters of oxygen used in one minute per kilogram of body weight."

Table-I: Peroperative and postoperative characteristics of patients (n=39).

S No.	Variables	n=39
1	Age (years) (Mean ± SD)	55.05 ± 10.12 Minimum = 38 Maximum = 74
2	Gender N (%)	Male = 35 (89.7%) Female = 4 (10.3%)
3	Height (cm) (Mean ± SD)	167.8 ± 6.31
4	Weight (kg) (Mean ± SD)	75.3 ±12.3
5	BMI Kg/m^2 (Mean ± SD)	26.8 ± 3.81
6	Per-op IABP N (%)	6 (15.4%)
7	CXP in minutes (Mean ± SD)	57.9 ± 27.2
	CBP in minutes (Mean ± SD)	98.8 ± 40.6
8	ICU stay (in hrs) (Mean ± SD)	61.9 ± 65.9
9	Ventilation (hours) N (%)	<24 hrs= 37 (94.9%) >24hrs= 2(5.1%)
10	Ionotropic requirement N (%)	Without Ionotrope = 3 (7.7%) Mild= 31 (79.5%) Moderate= 4(10.3%) Heavy= 1 (2.6%)
11	Post-op BIPAP use N (%)	62.7 ± 38.6
12	Peep (Mean ± SD)	6.31 ± 1.25
13	Respiratory Rate (Mean ± SD)	24.3 ± 8.84
14	FiO^2 (Mean ± SD)	50.9 ± 3.2
15	Re-operation N (%)	1 (2.6%)
16	Arrhythmia	22 (56.4%)
17	Infection	1 (2.6%)
18	Mortality	3 (8.1%)

Positive end-expiratory pressure (PEEP) is the positive pressure that will remain in the airways at the end of the respiratory cycle (end of exhalation) that is greater than the atmospheric pressure in mechanically ventilated patients. A method of ventilation in which airway pressure is maintained above atmospheric pressure at the end of exhalation by means of a mechanical impedance, usually a valve, within the circuit8.

Fraction of inspired oxygen (FIO2)is defined as the percentage or concentration of oxygen that a person inhales (the fraction of inspired oxygen). Supplemental O2 is an FIO2 >21%. Supplemental oxygen means an FIO2 greater than the 21% oxygen in room (ambient) air.

Bilevel Positive Airway Pressure (BiPAP) usage for this study is divided into two groups as >50 hrs and <50 hrs during the intensive care stay.

Cardiopulmonary exercise testing (CPET) was conducted using Brilliance 19S Medisoft cardio respiratory instrumentation) as per standard (modified McNaughten) protocol.Maximum oxygen consumption was recorded for patients after hospital admission.

Endpoints

The primary end points of the study were and incidence of postoperative pulmonary complications (PPCs), occurring within the first 30 postoperative days, BiPAP usage & prolonged ventilation time whereas in hospital mortality was the secondary end point. PPCs were collectedprospectively following preagreeddefinitions and included clinical diagnoses (pneumonia, bronchospasm, and/or ARD[9]), radiological diagnoses (presence of any degree or location of atelectasis, pneumothorax, and/or pleural effusion)[10] . Radiological diagnoses were reported by attending radiologists independent of the study, with the final consideration as PPC by the principle investigator.

Data Collection

A structured questionnaire was filled in for each patient; after informed written consent The clinical data was retrieved from our institutional cardiac surgery database.

Table-II: Radiological findings.

Minor Findings	Major Findings
Minimal pleural effusion	Large pleural effusion
Small atelectasis	Large atelectasis
Minimal pulmonary congestion	Severe pulmonary congestion
Small consolidation	Large consolidation
	Pneumothorax

1. Involvement of less than one lobe, and/or judged 'normal postoperative'.
2. Involvement of one lobe or more, and/or judged 'no normal postoperative finding'.

Data for the (VO2 max) maximum oxygen consumption were collected preoperatively by the cardiac surgeon in charge of the patient and research team at the time of hospital admission. The pulmonary gas exchange parameters recorded were VO2 max in mL/kg/min, Ve CO2 and VeO2.

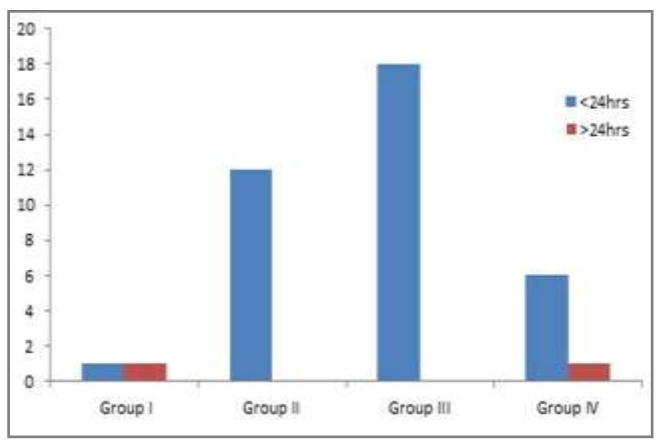

Figure-1: Association of Prolong Ventilation with VO2 Max readings (n=39).

We recorded general information (gender, height, weight and BMI), preoperative variables (hypertension, diabetes, chronic pulmonary disease, smoking status, cerebrovascular disease, coronary artery disease, chronic heart failure, recent myocardial infarction, previous cardiac intervention, angina class, NYHA class, ejection fraction, and intraoperative variables (Intraaortic balloon pump (IABP), cross clamp time (CXP) and bypass time (CPB). Postoperative parameters include ICU stay, ventilation time, ionotropic requirement, postoperative BIPAP usage, respiratory rate, FiO2, PEEP, arrhythmia, infection, reexploration and in hospital mortality. Post-operative inhospital pulmonary complications (PPC) were defined as the occurrence of at least one event during hospital stay.

Statistical Analysis

We summarized population characteristics, perioperative variables, PPCs, and outcomes. All values are represented as mean (SD) or number (percentage). The association between the PPCs (composite and individual PPCs) with demographic data, perioperative data, and clinical outcomes were examined with $\chi 2$ or Fisher exact tests for categorical variables and t test or Wilcoxon rank sum test for continuous variables. All analyses were performed using SPSS version 22. A 0.05 level of significance was used for all statistical tests previously mentioned.

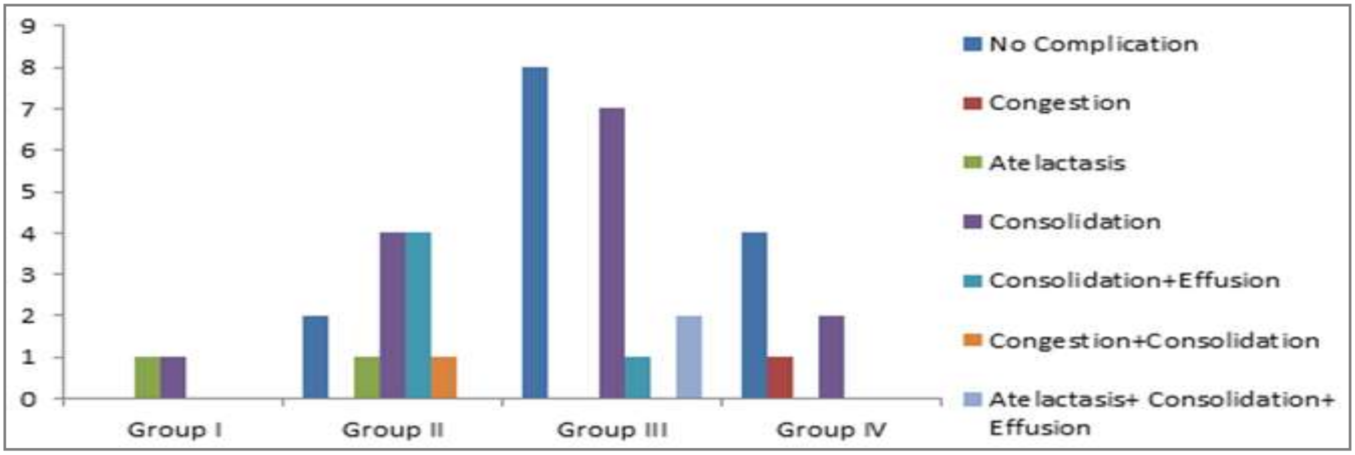

Figure-2: Association of pulmonary complication with VO2 Max readings.

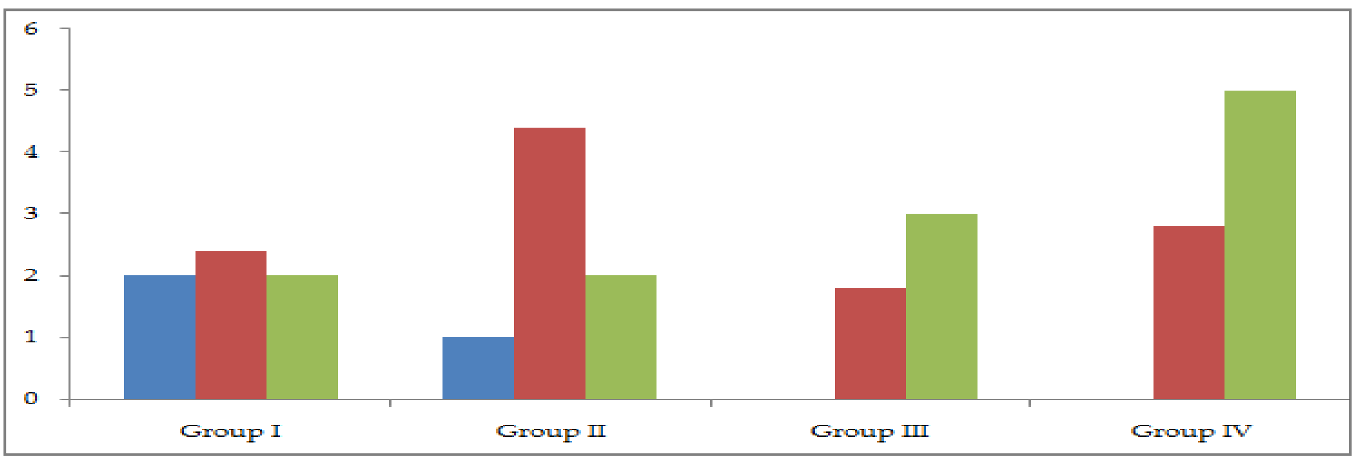

Figure-3: Association of in-Hospital Mortality with VO2 Max readings.

RESULTS

We analyzed the data of 39 eligible patients (Male 35 (89.7%), Female 4 (10.3%)). Mean age of our study population was 55.0 ± 10.2 years and a mean BMI of 26.8 ± 3.81. There were 20 (54.1%) hypertensives, 2 (5.4%) diabetics and 5 (13.5%) smokers. There was only one patient with a history of previous myocardial infarction (MI).

Majority of the patients belonged to NYHA class II 30 (76.9%) with a mean EF of 56.6 ± 5.17. The demographic and preoperative data is summarized in table-I.

In order to minimize bias and to improve the authenticity of our study results we divided our study population into four groups depending upon VO2 max readings as:

Group I <5ml/kg/min 2(5.4%),

Group II 6-10ml/kg/min = 11(29.7%)

Group III 11-15 ml/kg/min = 18(48.6%)

Group IV 16-20ml/kg/min = 6(16.2%).

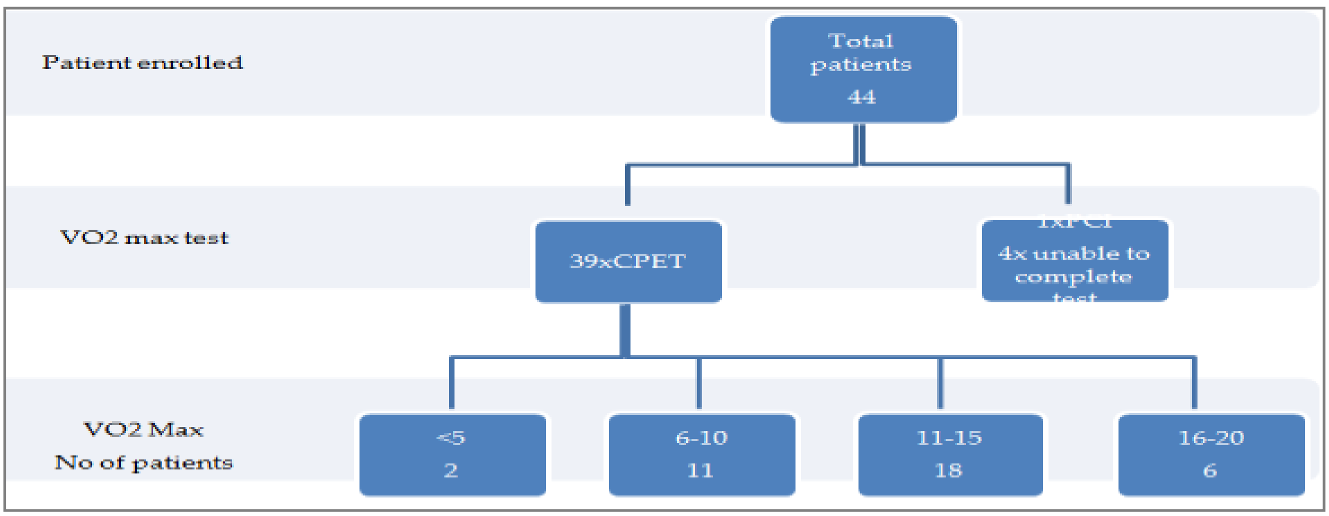

Figure-4: Patient selection protocol.

Prolonged ventilation (>24hrs) was significantly associated with lesser values of VO2max with a *p*-value of 0.01.Similarly, postoperative prolongedBiPAP usage (>50hrs)was reported more in group I as compared to other groups.

The incidence of postoperative pulmonary complications was significantly associated with lower values of VO2 max with a *p*-value=0.039. The occurrence was more in group I and group II.

Our study findings also document a higher mortality in patients with lesser values (group I & II) of VO2 max readings .

DISCUSSION

Coronary artery bypass graft surgery is associated with significant morbidity and mortality when compared to non cardiac surgical procedures. Over the years various risk stratification models have been developed to understand and predict the risks and there association in patients undergoing coronary artery disease[11-19]. Preoperative risk scores are an essential tool for risk assessment, cost benefit analysis and in decision making for the most appropriate management strategy.

Although most of the risk systems were primarily designed to predict mortality, postoperative morbidity has been acknowledged as the major determinant of hospital cost and quality of life after surgery[20]. Our study focuses on the preoperative functional status of the patient and evaluates the early postoperative outcomes.

The values of VO2 max in our study fall in the lower range as compared to the general population. Patients in our study had significant coronary artery disease (CAD), 28 (71.8%) had triple vessel, 9 (23.1%) had double and 2(5.1%) had single vessel coronary artery disease. Similar results were shown by Winter *et al*[21] in their work on patients with coronary artery disease where they demonstrated the extent of reduction in VO2 max had correlation with the extent of coronary artery disease.

Short postoperative ventilation times are accepted as a marker of quality. Prolonged postoperative ventilation time (>24 hours) after isolated CABG is a component of the publicly reported STS CABG composite score and is considered to be an unfavorable outcome[22]. We found a strong association between low preoperative VO2 max levels and the postoperative ventilation times (*p*-value 0.011).

In cardiac surgery patients postoperative pulmonary complications are associated with increased early postoperative mortality, ICU admission, and length of stay[23]. Atelectasis and pleural effusion are common after coronary artery bypass graft surgery [24]. The patients with lower values of preoperative VO2 max had more early minor and major postoperative pulmonary complications as assessed clinically and postoperative x-rays (*p*-value 0.039). In our work BiPAP usage was a poor indicator of post-operative pulmonary function (*p*-value 0.460).

Patients with low reserves VO2 max levels (VO2 max less than 10 ml/kg/min had a poor postoperative prognosis in our study population. We found a strong correlation between VO2 max levels and mortality (*p*-value 0.001). Similar results have been published in a review article by Paul O. Older and Denny ZH Levett[25]. In a systematic review of the literature Roberto Benzo, George A. Kelley, Recchi *et al*[26] found that exercise capacity expressed as VO2 max, is lower in patients that develop clinically relevant complications after curative lung resection.

Accurate preoperative risk stratification is important to direct perioperative care.We found a positive correlation between VO2 max values and hospital stay (*p*-value 0.029). Published work on colorectal surgery[27], major hepatobiliary surgery[28,29] abdominal aortic surgery[30] and with preoperative cardiopulmonary exercise testing have linked low VO2 max and anaerobic threshold with prolonged hospital stay. Similarly published research on major urological surgery also show low maximum oxygen extraction during preoperative CPET as a determinant for prolonged length of hospital stay[31-33].

CONCLUSION

We conclude from this study that VO2 max levels are correlated with postoperative outcome. Patients with cardiopulmonary fitness below the recommended cut-points are susceptible to postoperative complications and mortality.

Preoperative exercise programmes can improve fitness before surgery[34]. The ability of preoperative exercise interventions to improve postoperative outcome requires further vali-dation.

LIMITATION OF STUDY

Our study presents several limitations. Our findings reflect statistical associations and do not imply cause-effect relationships. Finally, our patient population was limited to only 40 patients and may limit the generalizability of our results to other populations. There is a need for multicenter prospective cohort studies to improve the precision of risk estimates for various patient groups and to clarify the best combination of variables to predict outcome. Early data suggest that preoperative exercise training improves fitness and may improve clinical outcomes.

ACKNOWLEDGEMENT

We would like to take this opportunity to express our gratitude to all consultants and coworkers of the Department of Adult Cardiothoracic Surgery for creating healthy and conductive environment of learning, clinical problems solving and effectively working as a team.

CONFLICT OF INTEREST

This study has no conflict of interest to be declared by any of its authors.

REFERENCES

1. Moran J, Wilson F, Guinan E, McCormick P, Hussey J, Moriarty J. Role of cardiopulmonary exercise testing as a risk-assessment method in patients undergoing intra-abdominal surgery: a systematic review.Br J Anaesth 2016; 116(2):177-91.
2. Moran J, Wilson F, Guinan E, McCormick P, Hussey J, Moriarty J. The preoperative use of field tests of exercise tolerance to predict postoperative outcome in intra-abdominal surgery: a systematic review. J ClinAnaesth 2016;35:446-455.

3. Effect of preoperative exercise on cardiorespiratory function and recovery aftercsurgery:a systematic review. World J Surgery 2013; 37:711-20
4. Paramesh K, BhagwatM.Cardio-pulmonary exercise testing: An objective approach to pre-operative assessment to define level of perioperative care. Ind J Anaesth 2010; 54(4).
5. Older P, Hall A, Halder R. Cardiopulmonary erxercise testing as a screening test for peri operative management of major surgery in elderly. Chest1999;116:355-62.
6. Tolchard S1, Angell J, Pyke M, Lewis S, Dodds N, Darweish A, White P, Gillatt D. Cardiopulmonary reserve as determined by cardiopulmonary exercise testing correlates with length of stay and predicts complications after radical cystectomy. JU Int 2015; 115(4):554-61.
7. Brunelli A. Peak Oxygen Consumption During Cardiopulmonary Exercise Test Improves Risk Stratification in Candidates to Major Lung Resection. Chest J 2009; 135(5).
8. Canet J1, Gallart L, Gomar C, Paluzie G, Vallès J, Castillo J, Sabaté S, et al. ARISCAT Group.Prediction of postoperative pulmonary complications in a population-based surgical cohort. Anesthesiology 2010;113(6):1338-50.
9. Mazo V, Sabaté S, Canet J, Gallart L, de Abreu MG,Belda J, et al. Prospective external validation of a predictive score for post-operative pulmonary complications.Anesthesiology 2014;121.
10. Parsonnet V, Dean D, Bernstein AD. A method of uniform stratification of risk for evaluating the results of surgery in acquired adult heart disease. Circulation 1989;79(suppl I)
11. Higgins TL, Estafanous FG, Loop FD, Beck GJ, Blum JM, Paranandi L. Stratication of morbidity and mortality outcome by preoperative risk factors in coronary artery bypass patients. J Am Med Assoc1992;267:234.
12. Hattler BG, Madia C, Johnson C, Armitage JM, Hardesty RL, Kormos RL, et al. Risk stratification using the Society of Thoracic Surgeons program. Ann Thorac Surg 1994;52:1348-52.
13. Roques F, Gabrielle F, Michel P, de Vincentiis C, David M, Baudet E. Quality of care in adult heart surgery: proposal for a self-assessment approach based on a French multicenter study. Eur J CardioThoracSurg 1995;9:433.
14. Tu JV, Jaglal SB, Naylor CD. Multicenter validation of a risk index for mortality, intensive care unit stay, and overall hospital length of stay after cardiac surgery. Circulation 1995;91:677-84.
15. Pons JMV, Granados A, Espinas JA, Borras JM,. Assessing open heart surgery mortality in Catalonia (Spain) through a predictive risk model. Eur J Cardio Thorac Surg 1997; 11:415-23.
16. Roques F, Nashef SAM, Michel P, Gauducheau E, de Vincentiis C, Baudet E, et al. Risk factors and outcome in European cardiac surgery: analysis of the Euro SCORE multinational database of 0 patients. Eur J Cardio Thorac Surg 1999;15: 816-23.
17. Nashef SAM, Roques F, Michel P, Gauducheau E, Lemeshow S, Salamon R. European system for cardiac operative risk evaluation (EuroScore). Eur J Cardio Thorac Surg 1999;16:9-13.
18. Tremblay NA, Hardy JF, Perault J, Carrier M. A simple classification of the risk in cardiac surgery: the first decade. Can J Anaesth 1993;40:103-111.
19. Higgins TL. Quantifying risk and assessing outcome in cardiac surgery. J Cardiothorac Vasc Anesth 1998;12:330-40.
20. Winter UJ, Gitt AK, Blaum M, Fritsch J, Berge PG, Pothoff G, et al. Cardiopulmonary capacity in patients with coronary heart disease1994;83 Suppl 3:73-82.
21. Jeffrey P. Jacobs, MD, Xia He. Variation in Ventilation Time After Coronary Artery Bypass Grafting: An Analysis From The Society of Thoracic Surgeons Adult Cardiac Surgery Database. Ann Thorac Surg 2013;96:757–62
22. Postoperative Pulmonary Complications, Early Mortality, and Hospital Stay Following Noncardiothoracic Surgery: Ana Fernandez-Bustamante, MD, PhD, GyorgyFrendl, MD, PhD, Juraj Sprung, MD, PhD. JAMA Surg 2017; 152(2): 157-66.
23. Moradian ST, Najafloo M, Mahmoudi H, Ghiasi MS. Early mobilization reduces the atelectasis and pleural effusion in patients undergoing coronary artery bypass graft surgery: A randomized clinical trial. Journal of Vascular Nursing 2017; 35(3): 141-45.
24. Paul O. Older and Denny Z. H. Levett. Cardiopulmonary exercise testing and surgery. Ann Am ThoracSoc 2017; 14(1):, S74–S83.
25. Benzo, George A. Kelley,LauraRecchi. Complications of lung resection and exercise capacity: a meta-analysis. Respir Med 2007; 101(8): 1790-97.
26. Lai CW, Minto G, Challand CP, Hosie KB, Sneyd JR, Creanor S, Struthers RA. Patients' inability to perform a preoperative cardiopulmonary exercise test or demonstrate an anaerobic threshold is associated with inferior outcomes after major colorectal surgery. Br J Anaesth 2013;111: 607-11.
27. Snowden CP, Prentis J, Jacques B, Anderson H, Manas D, Jones D, et al. Cardiorespiratory fitness predicts mortality and hospital length of stay after major elective surgery in older people. Ann Surg 2013;257: 999-1004.
28. Chandrabalan VV, McMillan DC, Carter R, Kinsella J, McKay CJ, Carter CR, et al. Pre-operative cardiopulmonaryexercise testing predicts adverse post-operative events and non-progression to adjuvant therapy after major pancreatic surgery.HPB (Oxford) 2013; 15:899–907.
29. Prentis JM, Trenell MI, Jones DJ, Lees T, Snowden CP. Submaximal exercise testing predicts perioperative hospitali zationafter aortic aneurysm repair. J Vasc Surg 2012; 56: 1564-70.
30. Prentis JM, Trenell MI, Vasdev N, French R, Dines G, Thorpe A,Snowden CP. Impaired cardiopulmonary reserve in an elderly population is related to postoperative morbidity and length of hospital stay after radical cystectomy. BJU Int 2013;112:E13–E19.
31. Ting SM, Iqbal H, Kanji H, Hamborg T, Aldridge N. Functional cardiovascular reserve predicts survival pre-kidney and post-kidney transplantation. J Am SocNephrol 2014;25: 187-95.
32. Tolchard S, Angell J, Pyke M, Lewis S, Dodds N, Darweish A, et al. Cardiopulmonary reserve as determined bycardiopulmonary exercise testing correlates with length of stay and predicts complications after radical cystectomy. BJU Int 2015;115:554-61.
33. Dronkers JJ, Lamberts H, Reutelingsperger IM. Preoperative therapeutic programme for elderly patients scheduled for elective abdominal oncological surgery: a randomized controlled pilot study. Clin Rehab 2010; 24: 614–22.

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