January 2005

Predicting postoperative cardio-pulmonary complications by a test of stair climbing

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ORIGINAL ARTICLE

PREDICTING POSTOPERATIVE CARDIOPULMONARY COMPLICATIONS BY A TEST OF STAIR CLIMBING

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ABSTRACT

Objective: To assess whether a test of stair climbing ability could be used to predict the risk of developing postoperative cardiopulmonary complications in patients undergoing general anesthesia.

Design: Cohort study.

Place and Duration of Study: The Aga Khan University Hospital, Karachi. The duration of the study was from December 2003 to December 2004.

Patients and Methods: This study was carried out on consecutive, adult patients presenting for elective thoracic or abdominal surgery under general anesthesia. Pre-operatively, patients were asked to climb a standard staircase. Number of steps climbed was recorded. Those unable to climb stairs due to debilitating cardiac, pulmonary or rheumatologic disease were categorized as 0 stairs climbed. Outcome variables were postoperative cardiopulmonary complications or mortality. Period of follow-up was until hospital discharge.

Results: Seventy-eight patients were enrolled; 59 (75.6%) climbed ≥1 flight of stairs, 19 (24.3%) climbed < 1 flight. All-cause cardiopulmonary complications rate was 26 %. The most frequent complication was lobar atelectasis, followed by bronchospasm and acute MI.

The complication rate was 22.8% in those able to climb ≥1 flight and 40% in those patients who climbed < 1 flight. The group that climbed < 1 flight tended to have complications associated with poor reserves of the cardiopulmonary systems; i.e. pulmonary edema, exacerbation of underlying lung disease. The relative risk of developing complications, if unable to climb at least 1 flight of stairs, was calculated to be 1.8 (95% CI 0.7 - 4.6).

Conclusion: Stair climbing can be a useful pre-operative tool to predict the risk of postoperative cardiopulmonary complications.

KEY WORDS: *Pre-operative evaluation. Stair climbing. Pulmonary function tests.*

INTRODUCTION

Cardiopulmonary complications are the most common cause of postoperative morbidity and mortality in patients who undergo surgery under general anesthesia. Reported rates range from 30% (upper abdominal and thoracic surgery) to 50% (esophagectomy).[1] Substantial efforts are made to pre-operatively risk stratify patients due to the high morbidity, mortality and monetary costs that result from the development of a complicated postoperative course.

Available guidetines[2] rely heavily on spirometry, arterial blood gas measurement and chest-X-rays. These tests, though useful for screening, are expensive and do not give a global assessment of cardiopulmonary reserves. Aerobic exercise stresses the cardiopulmonary system and can unmask hidden deficits in systemic oxygen transport.[3] Patients who are unable to generate high oxygen consumption (VO_2 max) with exercise testing may also be unable to do so under the demands placed by general anesthesia and surgery. Formal cardioputmonary exercise testing with measurement of VO_2 max has become well estabtished as a risk prediction tool in pre-operative assessment.[4,5]

Stair climbing is a simpte, cheap and widely applicable form of exercise testing that places a progressive burden on the cardiopulmonary system. Moreover, it has been supported as a pre-operative assessment tool in patients undergoing lung resection for malignancy.[6,7]

The objective of this study was to assess whether a test of stair climbing ability could be used to predict the risk of devetoping postoperative cardiopulmonary complications in patients undergoing general anesthesia.

PATIENTS AND METHODS

This was a prospective, cohort study carried out at a tertiary care, referral hospital in Karachi. Consecutive, adult patients scheduled for elective thoracic or abdominal surgery under general anesthesia were included. Patients with unstable cardiovascular disease or cardiac surgery were excluded from the study. All patients gave written and informed consent.

Enrolled patients underwent the usual pre-operative pulmonary evaluation as determined by the primary surgeon. In addition, they were asked to climb a hospital staircase. This

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Received March 14, 2005; accepted September 14, 2005.

was a 6-flight staircase with 3 landings. Each flight of stairs had 16 steps separated by a landing. Each step measured 6 inches high and 12 inches wide. The total height of the staircase was 40 feet. The patients were instructed to climb as far as possible at their own pace, using the railing only for balance. They were told to stop once they could not climb any more. Patients unable to climb stairs due to physical inability from severe cardiovascular, rheumatologic, pulmonary, or neurological disease were counted as climbing 0 stairs. No complications occurred during the stair climbing.

The surgical teams directed postoperative care without input from the research team. A research officer/pulmonary physician, blinded to the number of stairs climbed, reviewed the medical records and chest X-rays daily for postoperative cardiac and pulmonary complications. Complications were defined as: pneumonia (i.e., temperature >38°C for >48 hours without an identifiable extra-pulmonary source, plus purulent sputum and an infiltrate seen on chest X-ray), respiratory failure requiring prolonged mechanical ventilation (>48 hours after surgery) or reintubation, bronchospasm, atelectasis requiring medical or bronchoscopic intervention, hypercapnia ($PaCO_2$>50 mmHg or >10 mmHg over the baseline lasting for >48 hours after surgery), exacerbation of underlying lung disease, pulmonary embolism, death, pulmonary edema, myocardial infarction (elevated troponin I, ECG changed from baseline), hemodynamically unstable arrhythmia requiring treatment. Duration of follow-up was until hospital discharge. The study protocol was approved by the AKU Ethical Review Committee.

Data was analyzed using statistical package for social sciences (SPSS) version 13. Descriptive variables were reported as means ± SEM. Patients with and without complications were compared by Student's t-test for continuous variables and χ^2-test for categorical variables. A p-value of 0.05 was considered statistically significant. Relative risk of complications was calculated using a standard 2x2 table. Pearson correlation coefficients were calculated for association between complications and independent variables.

Results

Seventy-eight patients were enrolled from the period December 2003 - December 2004. There were 46 females and 32 males. Mean age was 50.8 (17 – 80) years. Thirteen patients had pre-existing pulmonary disease.

Cardiopulmonary complications developed in 26% patients (79% pulmonary and 21% cardiac). Eighteen patients had only one complication; one patient had more than one postoperative complication.

The most frequent pulmonary complication was lobar atelectasis requiring bronchoscopic intervention, followed by nosocomial pneumonia and bronchospasm. Pulmonary edema was the most frequent cardiac complication. There was no in-hospital mortality.

Fifty-nine patients (75.6%) climbed ≥ 1 flight of stairs, 19 (24.3%) climbed < 1 flight. Ten patients climbed 0 stairs. The mean number of stairs climbed was 17 ± 9.5. No patient climbed greater than 2 flights of stairs. The complication rate in the 19 patients that climbed < 1 flight was 40%. The complication rate in the 59 patients that climbed ≥1 flight of stairs was 22.8%. A statistically significant negative correlation was observed with the number of stairs climbed and the development of complications (r = 0.35, p-value <0.05). No statistically significant association was observed with FEV1, age or type of surgery.

The relative risk of postoperative complications, if unable to climb 1 flight of stairs, was calculated to be 1.8 (95% CI 0.7 - 4.6).

The ability to climb more than one flight of stairs resulted in a negative predictive value of 81% for developing postoperative complications. With a 1 flight cutoff, the sensitivity and specificity of a stair climb was calculated to be 35% and 80% respectively.

The group that climbed < 1 flight tended to have greater (10%) complications associated with poor reserves of the cardiopulmonary systems; i.e. acute MI, pulmonary edema, atelectasis, as compared to the group of patients that were able to climb more than one flight of stairs. However, this trend did not reach statistical significance.

Table I: Comparison of patients able to climb ≥1 flight of stairs with those climbing < 1 flight before surgery.

	≥1 Flight stairs	< 1 Flight stairs	p value (95%CI)
Number of patients	59	19	
Age	49.7 years(±15.7)	56.2 years(±16.5)	0.81
Gender	57.1% males	45.45% males	0.49
Type of Surgery			
Thoracotomy	49.1%	55%	
Sternotomy	3.5%	5%	
Esophagectomy	1.7%	-	
Upper abdominal surgery	22.8%	10%	
VATS	7%	10%	
laparotomy	12.3%	20%	
Other	3.5%	-	
PaCO2	36.2 torr(±5.31)	37.4 torr(±8.1)	0.50
FEV1 / FVC	77.8 (± 16.5)	71 (± 12.8)	0.11
FEV1	4.5 L (± 2.37)	1.3 L(± 0.17)	0.16
Complications Rate	22. 8%	40 %	RR * 1. 8 (0.7 - 4. 6)

*Data is presented as means ± 1 standard deviation; *Relative Risk = Risk of complications in those climbing < 1 flight; Risk of complications in those climbing ≥1 flight.*

Table II: Types of postoperative complications occurring in patients undergoing surgery.

Types of complications	≥1 Flight stairs	< 1 Flight stairs	Percent (no)
Pulmonary			
Atelectasis	1	3	21% (4)
Pneumonia	1	2	18% (3)
Bronchospasm	1	1	11%(2)
Exacerbation of underlying lung disease	2	0	11%(2)
Respiratory failure	0	1	5%(1)
Persistently elevated PaCO2	1	0	5%(1)
Cardiac			
Pulmonary edema	2	1	16%(3)
Acute MI	1	1	11%(2)
Arrhythmia	1	0	6%(1)

Some patients had more then one complication.

Discussion

Postoperative cardiopulmonary complications lead to failure to wean from mechanical ventilation, prolonged

hospitalizations, escalating healthcare costs and contribute to mortality. Pre-operative assessment that can risk stratify patients at high-risk of developing postoperative complications is one of the most important responsibilities of a pulmonary physician. Patient-related factors such as age, smoking status, general health, obesity and coexisting obstructive pulmonary disease are useful indicators of a complicated postoperative recovery.[2]

Pre-operative risk assessment with spirometry, MVV and FRC was first reported in 1955 by Gaensler and then further modified by reporting measurements as percentage of predicted normal values.[8] Increasingly, it is being recognized that static lung function assessment cannot give a correct estimation of the patient's ability to tolerate the oxidative stresses of surgery and general anesthesia. Functional capacity testing by aerobic exercise has been used to measure maximal oxygen consumption and anaerobic threshold. These have a prognostic importance after major non-cardiac surgery.[9] Exercise testing with 6 minute walk test, pulse oximetry or cycle ergometry correlates well with the development of postoperative complications. Ninan and coworkers[3] reported the usefulness of pulse oximetry during exercise, as a predictor of major morbidity and prolonged stay in an intensive care unit after pneumonectomy. Bechard and coworkers[10] and Eugene *et al.*[11] reported that VO_2 max measured by cardiopulmonary exercise testing is a powerful predictor of the risk of postoperative complications in patients undergoing thoracic surgery. A VO_2 max > 20ml/kg/minute is associated with a low risk of postoperative morbidity, whilst a VO_2 max <10 ml/kg/minute predicts a high all-cause morbidity and mortality rate. However, this testing is technically demanding, expensive and requires equipment not readily available in most Pakistani hospitals.

Exercise testing by stair climbing becomes an attractive proposition since no equipment is needed and it is easily understood by patients. In healthy volunteers, VO_2 max measured during stair climbing correlates well with measurements from treadmill exercise testing.[12] Pollock *et al.*[13] demonstrated that in patients with COPD, the number of steps climbed correlated linearly with peak VO_2 ($r = 0.72, p < 0.01$); or that climbing two flights of stairs correlated with a peak VO_2 of 12 ml/kg/minute, as compared to 5 flights of stairs which correlated with a peak VO_2 > 20 ml/kg/minute.

Stair climbing also correlates well with lung function. Patients who can climb upto 3 flights of stairs can be expected to have an FEV1 > 1.7 L[6]

A number of investigators have reported on the utility of stair climbing for pre-operative risk stratification of patients undergoing thoracic and or major surgery. Two retrospective studies reported on increased mortality in patients unable to climb more than 2 flights of stairs.[14,15] Prospective studies of small numbers of patients[16-22] mostly limited to thoracic surgery, also support the use of stair climbing tests as predictive of perioperative complications and mortality. A recent evaluation of 83 patients by Girish *et al.*[20] reported that the inability to climb 2 flights of stairs (36 steps) was associated with 82% positive predictive value for the development of a pulmonary complication in patients undergoing thoracotomy, sternotomy or upper abdominal surgery. Holden *et al.*[17] evaluated 16 high risk patients (FEV1 < 1.6 L) for post-lung resection complications. They found the inability to climb 45 steps had a 91% positive predictive value for a poor outcome. Brunelli and coworkers[21] demonstrated in 160 patients with lung cancer for lung resection, the altitude reached by stair climbing was an independent predictor of mortality; the incidence of postoperative pulmonary complications was 6.5% in the group able to climb > 14 meters compared to 79.2% in the group climbing < 14 meters (p-value = 0.003). A small, uncontrolled study on 19 patients from Thailand[23], reported a lower complication rate in patients able to climb over 5 flights of stairs.

In this study, performed on an average Pakistani population presenting for elective non-cardiac major surgery, we observed a postoperative cardiopulmonary complication rate of 26%. This is close to the incidence reported in the literature (20% to 60% for thoracic and upper abdominal surgery).[1,5,6] Our study population demonstrated poorer exercise capacities on the stair climbing test as compared to western samples. The maximum number of stairs climbed by any subject was 32. Ten patients were unable to climb any stairs at all (classed as 0 stairs). Despite this an almost two-fold greater relative risk of complications was observed in the cohort that climbed less than or equal to one flight (16 stairs) of stairs. Previous investigators have estimated that climbing one flight of stairs is equivalent to 5.5 METs or metabolic equivalents.[24]

We estimated a 35% sensitivity and 80% specificity of correctly predicting postoperative complications when a cutoff of 1 flights of stairs was used. These results are comparable to those obtained by Girish *et al.*[20], who reported a 38% sensitivity and 97% specificity when a cutoff of 2 flights was used in their study. Our results are limited by the inability of any of our study subjects to climb more than 2 flights of stairs. However, this may be representative of the average population in the Karachi area. Also, since there were no mortalities, we are unable to evaluate the impact of stair climbing as a prognostic tool after major surgery.

Conclusion

The ability to climb stairs may predict the risk of postoperative hospital morbidity in patients undergoing surgery. It identifies a simple assessment tool that is available to all physicians who have access to a building with stairs.

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