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Surgical risk tests related to cardiopulmonary postoperative complications. Comparison between upper abdominal and thoracic surgery[1]

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ABSTRACT

PURPOSE: To investigate if tests used in the preoperative period of upper abdominal or thoracic surgeries are able to differentiate the patients that presented cardiopulmonary postoperative complications.

METHODS: Seventy eight patients, 30 submitted to upper abdominal surgery and 48 to thoracic surgery were evaluated. Spirometry, respirometry, manovacuometry, six-minute walk test and stair-climbing test were performed. Complications from immediate postoperative to discharge from hospital were registered.

RESULTS: The postoperative complications rate was 17% in upper abdominal surgery and 10% in thoracic surgery. In the univariate regression, the only variable that kept the correlation with postoperative complications in the upper abdominal surgery was maximal expiratory pressure. In thoracic surgery, the maximal voluntary ventilation, six-minute walk test and time in stair-climbing test presented correlation with postoperative complications. After multiple regression only stair-climbing test continued as an important risk predictor in thoracic surgery.

CONCLUSION: The respiratory pressure could differentiate patients with complications in upper abdominal surgery, whereas in thoracic surgery, only spirometric values and exercise tests could differentiate them.

Key words: Thoracic Surgery. Abdominal Wound Closure Techniques. Exercise Test.

Introduction

The upper abdominal and thoracic surgeries are routinely performed for treatment of many diseases, and sometimes for diagnosis. Such surgeries can present cardiopulmonary postoperative complications (POC) more frequently than the lower abdominal surgeries, as due to the surgical incision interfering in the respiratory muscles as by the own changes caused by the surgery and anesthesia.

POC after upper abdominal surgery and thoracic surgery increase the morbidity and mortality rates, mainly in those ones presenting cardiopulmonary disturbs, and these two type of surgery present a high incidence of complications among major surgery[1,2]. POC result from the interaction of factors related to the general health of the patient and the surgical procedure to which it is subjected[3]. Such POC cause damages to the patients due to the long postoperative hospital stay as well as the high costs for health system.

Due to the high incidence of POC in major surgeries, the preoperative cardiopulmonary evaluation has to be performed in the preparation of such patients in order to predetermine those that would have higher risks to develop POC[4]. Consequently, it is possible to intensify the pre-operative care in order to minimize the POC.

Tests such isolated evaluation of lung volumes and capacity, respiratory muscle strength, as well as exercise tests to determine the cardiopulmonary capacity can be performed during preoperative period. Exercise tests can be those of maximal effort such as ergospirometry that measures the oxygen consumption (VO_2)[5] or submaximal effort such as stair-climbing test (SCT)[6-15] and six-minute walk test (6MWT)[9,16].

However, in spite of being well determined in thoracic surgery, there has not been a standardization in which tests to determine the most susceptible patients to develop postoperative complications should be used in the preoperative period of upper abdominal surgery. Surgical risk scales are routinely used to predict surgical risks, but relating to cardiopulmonary tests, little has been investigated yet[17,18].

Therefore the purpose of study was determining if tests performed in order to evaluate heart and lung function in the preoperative period of upper abdominal and thoracic surgery can differentiate the patients who have higher chances to develop postoperative complications and also which tests are more important concerning to each one intervention.

Methods

Study approved by the Research Ethics Committee from Botucatu School of Medicine - Sao Paulo State University - UNESP (REC 3336/2009). It was initiated by contacting all patients undergoing upper abdominal and thoracic surgery who agreed to participate signing the informed consent. The surgery was recommended according to the clinical conditions established by medical specialists and it was not denied due to unsatisfactory tests. Urgency and emergency surgeries and patients with any acute condition were excluded as well as the ones who presented vascular or musculoskeletal changes that would make walking difficult or the presence of nasogastric tube or drains. All patients were submitted to resting electrocardiogram before the exercise test performance. Seventy-eight patients were evaluated, 49 males (63%) and 29 females (37%) and the mean age was 55.6 ± 14.5 years.

Weight was measured in kilograms, and height in meters in order to calculate the body mass index (BMI). During preoperative period, in the maximum 30 days before the surgery, an interview and the following tests were performed: spirometry, peak expiratory flow, respirometry, manovacuometry, 6MWT and SCT.

Patients were submitted to spirometry according to the American Thoracic Society (ATS)[19] using Koko spirometer 606055®. At least three reproductive studies of Forced Vital Capacity (FVC) and Forced Expiratory Volume in the first second (FEV_1) in liters and percentage of predict, the ratio between two values FEV_1/FVC in percentage and maximal voluntary ventilation (MVV) in liters/minute and percentage of predict. In order to obtain the peak flow values, a maximal inspiration until total lung capacity was carried out and after an inspiratory pause of two seconds in the maximum a forced expiration was carried out through a nozzle of the device Mini-Wright® Peak Flow Med (Airmed), without the prolonged maneuvers to the residual volume, so a short explosive exhalation was carried out. Expired minute volume (MV) was obtained with the patient sitting, wearing a nose clip, breathing quietly for one minute in a spirometer Wright®. The tidal volume (TV) was determined by the formula: TV = MV/RR, where RR corresponds to respiratory rate.

Maximal inspiratory and expiratory pressures (MIP and MEP), were obtained according to the norms of ATS[19] in a manovacuometer (Salcas® MD 00983/08), with variation capacity of -200 to +200 cmH_2O.

Six-minute walking test was carried out in a 120 meters long corridor, divided in marks of 0.75 m and in the shade and was performed according to ATS[19]. Previously and at the end of the test, the heart rate (HR), respiratory rates (RR), oxygen saturation (SpO_2) and Borg Scale[20] were evaluated. The calculation of the predicted distance in the 6MWT was carried out with the equation proposed by Soares and Pereira[21].

SCT was carried out in a six flights staircase in the shade, 12 steps each flight in a total of 12.16 m height, as standardized by Cataneo and Cataneo[11]. The time in seconds was taken in the end of the staircase ascent and was named time of stair climbing test (tSCT) and the power (P) in watts (w) was calculated using the classic formula[11].

The patients were followed up during the postoperative period (PO) and the cardiopulmonary complications, if present, were registered: acute myocardial infarction, unstable angina pectoris, congestive heart failure, arrhythmias requiring therapy, reintubation, prolonged intubation for more than 24-hours, pneumonia, atelectasis that required bronchoscopy, pulmonary thromboembolism, $PaCO_2$ higher or equal to 50 mmHg and death. Length of stay in Intensive Care Unit and in hospital stay were also registered.

The data was analysed initially evaluating if the variables had a normal distribution by Shapiro-Wilki test in order to differentiate groups that presented complications and the ones that did not present complications, as well as to compare the two kinds of surgery studied. Student's test was used when such variables presented normal distribution and Mann-Whitney test when they had not normal distribution. Univariate logistic regression was used in order to verify which variables were associated with the POC, where the variables that were significant in this model, were analyzed in a multiple logistic regression. The significance level considered was $p<0.05$ and the program used was SAS (Statistical Analysis System), version 9.2.

Results

Initially, 208 patients were selected to upper abdominal surgery (UAS Group) and thoracic surgery (TS Group), 92 in UAS Group and 116 in TS Group. From the patients selected in UAS Group, there was a loss of five patients (three due to the cancellation of surgery; one due to alteration of procedure in the intraoperative and one due to the need of interrupting the tests to be submitted to other interventions). There was a loss of 57 patients in TS Group, but all of them related to alterations on surgical procedures and suspended surgery. Fifty seven patients were excluded in UAS Group and eleven in TS Group according exclusion criteria.

Seventy eight patients were evaluated; 30 in UAS Group and 48 in TS Group. The patients were divided into two subgroups according to POC absence (A) or presence (P). Five patients (17%) from UAS Group presented POC (subgroup UAP) and five (10%) from TS Group (subgroup TP). The complications that occurred in the upper abdominal surgery for each patient were: prolonged intubation and death; prolonged intubation, reintubation and death; pneumonia; reintubation, pneumonia and death; arrhythmias requiring intervention. Four complications had pulmonary origin and one cardiac origin and three deaths occurred in this subgroup. The complications in the thoracic surgery were: prolonged intubation in two cases; pneumonia and death; pulmonary thromboembolism; prolonged intubation and reitubation. All the complications in the thoracic surgery had pulmonary origin and one death occurred in this subgroup.

Demographics according to the groups and p values are presented on Table 1. When the muscle strength and spirometry were analyzed, it was noticed that the thoracic group achieved better respiratory pressures, but the spirometry was better in the upper abdominal surgery group. However, related to exercise tests there were not great differences between the groups (Table 1).

Demographics according subgroups and p values are presented on Table 2. The subgroup TP is significantly older than TA. The length of stay in the intensive care unit (ICU) was significantly higher in the subgroups presenting complications (UAP and TP) (Table 2). The mean length of stay and surgery were significantly higher only in the subgroup TP (Table 2).

TABLE 1 - The comparison of variables between two groups: upper abdominal surgery (UAS Group) and thoracic surgery (TS Group). Mean ± standard deviation or median (1º and 3º quartile) and p.

VARIABLES	UAS	TS	p
Age (years)	58.4±9.9	54.0±16.7	0.0733
weight (Kg)	63.5±10.5	67.4±14.9	0.0921
height (cm)	159.5±8.5	163.5±8.4	0.0221*
BMI (kg/m²)	25.1±4.2	25.2±5.1	0.4616
t surgery (minute)	247.5(61.3, 433.7)	172.5 (32.5, 312.5)	0.0058*
t anesthesia (minute)	324.3±139.2	272.3±113.2	0.0374*
t discharge (day)	8.0 (3.3, 12.7)	5.0 (2.0, 8.0)	< 0.0001*
t ICU (day)	0.0 (0.0, 0.0)	0.0 (-1.0, 1.0)	0.0617
MV (L)	10.4±2.6	11.3±3.0	0.0862
PEF (L/min)	372.8±119.6	374.3±122.7	0.4800
MIP (cmH_2O)	72.5±22.1	82.9±27.9	0.0438*
MIP %	74.4±22.1	83.5±21.8	0.0392*
MEP (cmH_2O)	92.0±29.7	103.9±38.0	0.0750
MEP %	85.7±24.0	100.6±28.7	0.0100*
FVC (L)	3.3 (2.3, 4.3)	2.9 (1.8, 4.0)	0.0200*
FVC %	107.3±14.9	90.5±18.7	< 0.0001*
FEV_1 (L)	2.6±0.6	2.3±0.7	0.0084*
FEV_1%	105.2±16.9	83.3±22.6	< 0.0001*
FEV_1/FVC	0.8 (0.7, 0.9)	0.7 (0.6, 0.8)	0.0040*
MVV (L/min)	111.4±33.0	104.2±38.3	0.2002
MVV %	109.8±28.1	96.6±26.8	0.0228*
6MWT (m)	505.5±87.9	523.6±84.7	0.1847
6MWT %	95.3±14.8	95.7±12.0	0.4503
tSCT (seg)	51.0 (33.5, 68.5)	47.5 (28.8, 66.2)	0.2571
P (w)	150.1±47.1	173.8±69.9	0.0442*

t – time; BMI - body mass index; ICU – intensive care unit. MV - Expired minute volume; PEF - Peak expiratory flow; MIP – maximal inspiratory pressure; MEP – maximal expiratory pressure; FVC - Forced Vital Capacity; FEV_1 - Forced Expiratory Volume in the first second; MVV - maximal voluntary ventilation;6MWT - 6-minute walk test; tSCT – stair climbing test; P – power;% - percentage of predict. * p< 0.05.

TABLE 2 - Age, weight, height, body mass index and time of surgery, anesthesia, stay in hospital and in intensive care unit, in the subgroup upper abdominal surgery absence (UAA) and presence of complications (UAP), and subgroup thoracic surgery absence (TA) and presence of complications (TP). Mean ± standard deviation or median (1º and 3º quartile) and p values.

VARIABLES	UAA	UAP	p	TA	TP	p
Age (years)	57.4 ± 9.9	63.0 ± 9.7	0.129	52.5 ± 16.8	66.2 ± 9.7	0.041*
weight (Kg)	63.9 ± 11.2	61.6 ± 6.5	0.331	67.5 ± 14.6	66.3 ± 18.8	0.433
height (cm)	160.0 ± 8.8	156.8 ± 7.4	0.227	163.7 ± 8.3	161.8 ± 10.0	0.319
BMI (kg/m²)	25.0 ± 4.5	25.1 ± 2.6	0.490	25.2 ± 5.2	24.9 ± 4.6	0.455
t surgery (min)	200.0 (30.0, 370.0)	300.0 (175.0, 425.0)	0.066	185.2 ± 101.2	273.0 ± 125.9	0.040*
t anesthesia (min)	312.4 ± 145.4	384.0 ± 90.6	0.151	225.0 (100.0, 350.0)	305.0 (180.0, 430.0)	0.055
t discharge (day)	8.0 (4.0, 12.0)	22.0 (8.0, 36.0)	0.080	4.0 (2.0, 6.0)	15.00 ± 10.0	0.001*
t ICU (day)	0.0 (0.0, 0.0)	5.0 (1.0, 9.0)	0.005*	0.0 (-1.0, 1.0)	5.0(-4.0, 14.0)	0.001*

t – time; BMI - body mass index; ICU – intensive care unit. *p<0.05

Spirometric variables FVC, FEV_1 and MVV were significantly lower only for the patients that presented complications in TS Group and the same occurred regarding to MIP and MEP for the patients that presented complications in UAS Group (Table 3). The exercise tests only had significant differences in TS, not significantly different UAS group relative to patients with or without complications (Table 4).

TABLE 3 - Respirometry, peak expiratory flow, manovacuometry, spirometric variables in the subgroup upper abdominal surgery absence (UAA) and presence of complications (UAP), and subgroup thoracic surgery absence (TA) and presence of complications (TP). Mean ± standard deviation or median (1º, 3º quartile) and p values.

VARIABLES	UAA	UAP	p	TA	TP	p
EMV (L)	10.4 ± 2.7	10.60 ± 2.21	0.433	10.8 (6.2, 15.4)	11.9 (9.7, 14.1)	0.4132
PEF (L/min)	375.4 ± 126.9	301.2 ± 101.3	0.139	2.5 (1.5, 3.5)	2.3 (1.5, 3.1)	0.0603
MIP (cmH_2O)	75.8 ± 22.2	56.0 ± 12.4	0.033*	80.0 (40.0, 120.0)	60.0(55.0, 65.0)	0.0583
MIP %	77.9 ± 21.0	56.8 ± 14.0	0.024*	83.6 (50.6, 116.6)	74.4 (60.4, 88.4)	0.1681
MEP (cmH_2O)	96.0 ± 29.4	72.0 ± 24.1	0.049*	95.0 (50.0, 140.0)	65.0 (50.0, 80.0)	0.0491*
MEP %	90.0 ± 21.9	63.5 ± 24.1	0.011*	94.3 (57.8, 130.8)	83.5 (54.5, 112.5)	0.3366
FVC (L)	3.4 ± 0.8	3.3 ± 0.6	0.354	3.1 ± 0.8	2.3 ± 0.5	0.0102*
FVC %	105.8 ± 14.7	114.4 ± 14.9	0.123	92.2558 ± 18.1359	75.2 ± 18.2	0.0262*
FEV_1 (L)	2.7 ± 0.6	2.58 ± 0.54	0.397	2.3 ± 0.7	1.6± 0.4	0.0139*
FEV_1%	103.0 ± 15.5	116.2 ± 21.5	0.055	85.3 ± 22.2	66.2 ± 20.9	0.0364*
FEV_1/FVC	0.8 (0.7, 0.9)	0.8 (0.7, 0.9)	0.401	0.7 ± 0.1	0.7 ± 0.1	0.1831
MVV (L/min)	113.0 ± 30.3	103.8 ± 47.6	0.288	102.9 (46.2, 159.6)	68.3 (51.4, 85.2)	0.0064*
MVV %	110.80 ± 25.87	104.6 ± 41.0	0.330	103.0 (68.8, 137.2)	59.5 (45.0, 74.0)	0.0019*

EMV - Expired minute volume; PEF - Peak expiratory flow; MIP – maximal inspiratory pressure; MEP - – maximal expiratory pressure; FVC - Forced Vital Capacity; FEV_1 - Forced Expiratory Volume in the first second; MVV - maximal voluntary ventilation; % - percentage of predict. *p < 0.05.

TABLE 4 - Stress test variables in the subgroup upper abdominal surgery absence (UAA) and presence of complications (UAP), and subgroup thoracic surgery absence (TA) and presence of complications (TP). Mean ± standard deviation or median (1º, 3º quartile) and p values.

VARIABLES	UAA	UAP	p	TA	TP	p
6MWT (m)	509.6 ± 80.5	485.1 ± 128.1	0.289	533.8 ± 78.7	435.4 ± 91.9	0.0062*
6MWT %	95.5 ± 14.5	94.3 ± 17.9	0.432	96.9 ± 11.2	85.5 ± 14.7	0.0215
tSCT (seg)	52.0 (37.0, 67.0)	41.0 (23.0, 59.0)	0.212	46.0 (31.0, 61.0)	87.0 (57.0, 117.0)	0.0012*
P (w)	149.5 ± 43.2	158.0 ± 69.5	0.360	182.0 ± 67.8	103.3 ± 48.1	0.0077*

6MWT - 6- minute walk test; tSCT – stair climbing test; P – power; % - percentage of predict .* $p < 0.05$.

Univariate logistic regression model were tested in UAS and TS groups evaluating FEV_1%, MVV%, MIP%, MEP%, 6MWT and tSCT variables. The only variable that presented a significant correlation with POC in UAS Group was MEP%, as a protective capacity, observing that each 1% increase of MEP value, the chance to develop POC decreases 6% (OR=0.95; IC95% = 0.897-0.998, p=0.0418). A significant correlation with POC in TP Group was found in MVV%, 6MWT and tSCT. MVV% presented itself as a protective factor, where at each 1% increase, POC chance decrease 7% (OR=0.93; IC95%=0.875-0.990; p=0.0222). Six-MWT also found a protection factor and every increase of 10 meters in the end of test, the chance to develop POC decrease 20% (OR=0.98; IC95%=0.969-0.998; p=0.025). The tSCT was considered a risk factor in the thoracic surgeries, because raise in one second to climb the stairs increase 9.5% the risk to develop POC (OR=1.09; IC95%=1.025-1.169; p=0.0071).

The variables that presented significant correlation in univariate model for TS Group were tested in multivariate logistic regression. The final model had MVV% and tSCT and every second the patient increase climbing the stairs raise 8.2% the chance developing POC (OR=1.082; IC95%=1.004-1.165; p=0.396). MVV% was no longer significant in this model.

Discussion

It was already demonstrated that patients submitted to upper abdominal surgery have an increased chance to develop postoperative complications. Although there are a lot of tests used in pre-operative evaluations and an attempt to identify those which predict the susceptibility to POC, the efficacy of each one in order to predict complications is still limited in such kind of surgery. The supine position during upper abdominal surgery, the incision near the respiratory muscles and the use of painkillers are responsible for peri and postoperative physiological changes. Lung volumes alterations and functional respiratory muscle deficiency occurs leading to mucociliary defense mechanisms disability and to microatelectasis[22].

Patients submitted to procedures that involve the chest wall had high rates of POC at the same way, even without a lung parenchyma resection. Surgical incision affects the integrity of the respiratory muscles and its function and general anesthesia effects interferes in respiratory muscle contraction[23]. Pathophysiological changes of thoracic surgery involves gas exchange, ventilatory patterns, pulmonary volumes and defense mechanisms of respiratory system, but mostly surgical aggression brings important morbidity and mortality in borderline patients[24].

Intraoperative variables

The time of surgery was higher in the POC subgroups, with significant difference in TS Group and had no significant but tending to be higher in UAS Group. Surgical time and POC correlation does not have so much value alone because many other factors may have interfered in the occurrences of POC, but such fact should warn not to extend the surgical time. Other studies have already demonstrated that the extended surgical time is related to pulmonary complications[17].

In order to perform these surgeries, the patients were submitted to general anesthesia, which can alter the form and the pattern of chest wall movements what can lead to changes in the elastic properties of the lungs and in the gas distribution[25]. Additionally general anesthesia affects diaphragmatic function due to the relaxing of muscular fibers and also decrease mucociliary clearance predisposing POC mostly if it is prolonged[26]. In the present study, the time of anesthesia was higher in the subgroups that presented complications and can have contributed for the occurrence of POC. The more extended surgeries in the UAS Group may be contributed for a higher rate of POC leading to a significant increase in the hospital length of stay.

Lung volumes and capacity

The upper abdominal surgery demonstrably affects the function of respiratory muscles mainly involving diaphragmatic function. Sometimes it is caused by direct trauma due to the surgical incision and most of them due to reflex inhibition of phrenic nerve after manipulation of abdominal viscera leading to changes in breathing patterns predisposing to respiratory complications[4,23]. The significantly lower spirometric values found in TS Group compared to UAS Group, demonstrate that respiratory disease is responsible for lung function deterioration. Pulmonary function, once reduced and allied to a higher decrease in the postoperative period from thoracic surgery[25] lead to a shortness of breathing and favors to pulmonary complications.

The spirometric variables were able to differentiate the subgroup that presented complications in TS Group, which were significantly lower in POC group. That fact demonstrated the importance of the exam in the preoperative preparation of patients that had spirometric values below predicted, mainly for MVV% that also had a protective correlation in the univariate regression. Such variables did not present a significant difference between the subgroups in UAS Group, leading us to question if these exams are necessary. Some studies demonstrated correlations with lower spirometric values and higher rates of POC[27,28] however, other believe that spirometry is not necessary in elective upper abdominal surgery in the absence of medical history, respiratory symptoms, history of smoking and chronic lung disease[29,30]. Nevertheless, it is important to highlight that spirometry should not be totally discarted in elective upper abdominal surgery, but should be performed according to a higher indication criteria to provide data about risk of POC[30]. In the other hand, pulmonary function tests have been considered a good predictor of surgical risk in thoracic surgery[31].

Respiratory muscle strength

Previous studies in thoracic surgery found out that patients who had unresponsive respiratory muscle strength to training have higher probability to develop POC[32,33]. Hulzebos *et al*.[34] found out that MEP values higher than 75% had POC protective effect in cardiac surgery. Bellinetti *et al*.[35] concluded more recently that the abnormal respiratory muscle strength during preoperative period of thoracic surgery and elective upper abdominal surgery was associated to a higher incidence of POC or death and when abnormal can be considered a risk factor. However, an association between the respiratory pressures and POC was not found in TS Group from the present study.

In fact all these studies considered just pulmonary POC while the present study considered also the cardiac POC. Another difference concerning the study methodology is that some authors[32,33] used fixed reference values, regardless age and gender, while Bellinetti's[35] and the present study used the predict values in percentage.

Manovacuometry was the only test proposed that determined a significant difference in the subgroups of upper abdominal surgery but only MEP% had POC protective correlation. Respiratory pressures in the present study were significantly lower in the UAS Group, probably due to the own interference of abdominal disease that can cause a discomfort during tests. These pressures were able to differentiate the POC subgroup and made it more important than spirometry in this group. For that group, in order to minimize POC, patients with reduced respiratory pressures should be submitted to preoperative preparation[36].

Cardiopulmonary exercise test

Exercise determines an increase in lung ventilation and perfusion, accelerating the gas exchange as well as in the postoperative of major surgeries[12]. At that way, cardiopulmonary exercise tests evaluate patient fitness and are able to identify defects in oxygen transport system. VO_2 obtained during ergospirometry is considered the gold standard to determine the capacity of exercise[37], but due to the fact it is an expensive equipment not available in most of hospitals, field tests can be used for it (6MWT, SCT).

Six-minute walking test is widely used to determine the physical capacity in several diseases as well as post-treatment assessment, nevertheless in pre-operative evaluations it has not been so wide explored. Holden *et al*.[9] identified that a shorter distance in walking tests can help to determine morbidity, mortality and also the need for prolonged mechanical ventilation. Szekely *et al*.[16] used 6MWT for COPD patients in the pre-operative of bullectomy and the distance had a significant correlation with hospital length of stay. According to these authors patients that walk less than 200 meters have a higher risk of postoperative death[16].

Exercise tests, either 6MWT or SCT, are able to differentiate the subgroups with or without complications in the TS Group but it is not the same in UAS Group probably because such tests are dependent on spirometry rather than respiratory muscle strength.

The degree of limitation becomes proportional to the degree of lung function impairment in patients that have difficult to climb stairs[38]. Previous studies found a strong correlation between SCT and complications after pulmonary resection. Olsen *et al*.[8] correlated the number of flights climbed in SCT to POC and concluded the higher number of flights climbed the lower the incidence of POC as well as lesser hospital length of stay. Girish *et al*.[10] have determined in their study that patients who climb around 13.4 meters don't have POC and recently Brunelli *et al*.[12] demonstrated that patients who climb less than 12 meters have more POC. All patients included in the present study climbed the whole stair (12.16 meters) but despite limited height, the speed of ascent can vary, so our option to use the time of SCT as other authors[14]. Epstein *et al*.[39] observed those who are not able to perform SCT had 79% POC compared to 35% of those ones who are able to perform the test. Brunelli *et al*.[40] also verified that patients unable to perform maximal exercise tests have a higher risk of mortality. There is not a standardization to perform SCT and evaluating physical capacity using different variables makes the comparison between the results difficult and also impossible to determine a cut-off point. Despite there is a lot of SCT studies, nothing has been done in upper abdominal surgery that demonstrate its importance isolated. This fact motivated us to study this test also in upper abdominal surgery to determine the risk of POC but the time in SCT demonstrated to be the single risk predictor only in thoracic surgery.

The search for ideal tests to predict the risk of postoperative complications is important to minimize it and even if it is not possible to modify it, it is important to be aware of POC. Since the attention and care should be intensified for high risk patients, the present research lead us to believe that the best preoperative preparation for upper abdominal surgery is to improve the respiratory muscle strength, while for thoracic surgery is to improve spirometric values as well as exercise capacity.

Conclusions

Respiratory pressures were able to differentiate the patients that presented complications in upper abdominal surgery, but only MEP% presented POC protective correlation. Spirometric values and exercise tests differentiated the POC group in thoracic surgery, where MVV% and 6MWT correlated as POC protective factors and tSCT as POC risk factor but only tSCT was predictor of POC in multivariate analysis.

References

1. Ginsberg RJ, Hill LD, Eagan RT, Thomas P, Mountain CF, Deslauriers J. Modern 30 day operative mortality for surgical resection in lung cancer. J Thorac Cardiovasc Surg. 1983;86:654-8.
2. Lawrence VA, Hilsenbeck SG, Muldrow CD, Dhanda R, Sapp J, Page CP. Incidence and hospital stay for cardiac and pulmonary complications after abdominal surgery. J Gen Intern Med. 1995;10:671-8.
3. Roukema JA, Carol EJ, Prins JG. The prevention of pulmonary complications after upper abdominal surgery in patients with non compromised pulmonary status. Arch Surg. 1988;123:30-4.
4. Ferguson MK. Preoperative assessment of pulmonary risk. Chest. 1999;115(Suppl 5):S58-3.
5. Benzo R, Kelley GA, Recchi L, Hofman A, Sciurba F. Complications of lung resection and exercise capacity: a meta-analysis. Respir Med. 2007;101:1790-7.
6. Souders CR. Clinical evaluation of the patient for thoracic surgery. Surg Clin North Am. 1961;41:545-56.
7. Van Nostrand D, Kjelsberg MD, Humphrey EW. Pre-resectional evaluation of risk from pneumonectomy. Surg Gynecol Obstet. 1968;127:306-12.
8. Olsen GN, Bolton JWR, Weiman DS, Hornung CA. Stair climbing as an exercise test to predict the post-operative complications of lung resection. Chest. 1991;99:587-90.
9. Holden DA, Rice TW, Stelmach K, Meeker DP. Exercise testing, 6 minute walk, and stair climb in the evaluation of patients at high risk for pulmonary resection. Chest. 1992;102:1774-9.
10. Girish M, Trayner E, Dammann O, Pinto-Plata V, Celli B. Symptom-limited stair climbing as a predictor of postoperative cardiopulmonary complications after high-risk surgery. Chest. 2001;120:1147-51.
11. Cataneo D, Cataneo AJM. Accuracy of the stair-climbing test using maximal oxygen uptake as the gold standard. J Bras Pneumol. 2007;33:128-33.
12. Brunelli A, Refai M, Xiumé F, Salati M, Marasco R, Sciarra V, Socci L, Sabbatini A. Oxygen desaturation during maximal stair-climbing test and postoperative complications after major lung resections. Eur J Cardiothorac Surg. 2008;33:77-82.
13. Brunelli A, Refai M, Xiumé F, Salati M, Sciarra V, Socci L, Sabbatini A. performance at symptom-limited stair-climbing test is associated with increased cardiopulmonary complications, mortality, and costs major lung resection. Ann Thorac Surg. 2008;86:240-8.
14. Koegelenberg CFN, Diacon AH, Irani S, Bolliger CT. Stair climbing in the functional assessment of lung resection candidates. Respiration. 2008;75:374-9.
15. Cataneo DC, Kobayasi S, Carvalho LR, Paccanaro RC, Cataneo AJM. Accuracy of six minute walk test, stair test and spirometry using maximal oxygen uptake as gold standard. Acta Cir Bras. 2010;25:194-200.
16. Szekely LA, Oelberg DA, Wright C, Johnson DC, Wain J, Trotman-Dickenson B, Shepard JA, Kanarek DJ, Systrom D, Ginns LC. Preoperative predictors of operative morbidity and mortality in COPD patients undergoing bilateral lung volume reduction surgery. Chest. 1997;111:550-8.
17. Filardo FA, Faresin SM, Fernandes ALG. Validade de um índice prognóstico para ocorrência de complicações pulmonares no pós-operatório de cirurgia abdominal alta. Rev Assoc Med Bras. 2002;48:209-16.
18. Paisani DM, Chiavegato LD, Faresin SM. Lung volumes, lung capacities and respiratory muscle strength following gastroplasty. J Bras Pneumol. 2005;31:125-32.

19. American Thoracic Society. ATS statement: guidelines for six-minute walk test. Am J Respir Crit Care Med. 2002;166:111-7.
20. Borg GA. Psychophysical bases of perceived exertion. Med Sci Sports Exerc. 1982;4:377-81.
21. Soares MR, Pereira CAC. Teste de caminhada de seis minutos: valores de referência para adultos saudáveis no Brasil. J Bras Pneumol. 2011;37(5):576-83.
22. Rudra A, Sudipta D. Postoperative pulmonary complications. Indian J Anaesth. 2006;50(2):89-98.
23. Siafakas NM, Mitrouska I, Bouros D, Gorgopoulos D. Surgery and the respiratory muscles. Thorax. 1999;54:458-65.
24. Nomori H, Horio H, Fuyuno G, Kobayashi R, Yashima H. Respiratory muscle strength after lung resection with special reference to age and procedures of thoracotomy. Eur J Cardiothorac Surg. 1996;10:352–8.
25. Tisi GM. Preoperative evaluation of the pulmonary function. Am Rev Respir Dis. 1979;119:293-310.
26. Jaffer AK, Barsoum WK, Krebs V, Hurbanek JG , Morra N , Brotman DJ. Duration of anesthesia and venous thromboembolism after hip and knee arthroplasty. Mayo Clin Proc. 2005;80:732-8.
27. Kocabas A, Kara K, Ozgur G, Sonmez H, Burgut R. Value of preoperative spirometry to predict postoperative pulmonary complications. Respir Med. 1996;90:25-33.
28. Barisione G, Rovida S, Gazzaniga GM, Fontana L. Upper abdominal surgery: does a lung function test exist to predict early severe postoperative respiratory complications? Eur Respir J. 1997;10:1301–8.
29. American College of Physicians Position Paper. Preoperative pulmonary function testing. Ann Intern Med. 1990;112:793–4.
30. Pereira EDB, Faresin ALG, Fernandes ALG. Morbidade respiratória nos pacientes com e sem síndrome pulmonar obstrutiva submetidos à cirurgia abdominal alta. Rev Assoc Med Bras. 2000;46:15-22.
31. Smetana GW. Preoperative pulmonary evaluation. N Eng J Med. 1999;340(12):937-44.
32. Nomori H, Kobayashi R, Fuyuno G, Morinaga S, Yashima H. Preoperative respiratory muscle training. Assessment in thoracic surgery patients with special reference to postoperative pulmonary complications. Chest. 1994;105:1782-8.
33. Nomori H, Kobayashi R. Postoperative pulmonary complications in patients undergoing thoracic surgery with special reference to preoperative respiratory muscle strength and nutrition. Nippon Kyobu Geka Gakkai Zasshi. 1994;42:1272-5.
34. Hulzebos EH, Van Meeteren NL, De Bie RA, Dagnelie PC, Helders PJ. Prediction of postoperative pulmonary complications on the basis of preoperative risk factors in patients who had undergone coronary artery bypass graft surgery. Phys Ther. 2003;83:8-16.
35. Bellinetti LM, Thomson JC. Avaliação muscular respiratória nas toracotomias e laparotomias superiores eletivas. J Bras Pneumol. 2006;32:99-105.
36. Galvan CCR, Cataneo AJM. Effect of respiratory muscle training on pulmonary function in preoperative preparation of tobacco smokers. Acta Cir Bras. 2007;22:98-104.
37. Schuurmans MM, Diacon AH, Bolliger CT. Functional evaluation before lung resection. Clin Chest Med. 2002;23:159-72.
38. Pollock M, Roa J, Benditt J, Celli B. Estimation of ventilator reserve by stair climbing: a study in patients with chronic airflow obstruction. Chest. 1993;104:1378-83.
39. Epstein SK, Faling LJ, Daly BD, Celli BR. Inability to perform bicycle ergometry predicts increased morbidity and mortality after lung resection. Chest. 1995;107:311-6.
40. Brunelli A, Sabbatini A, Xiume F, Borri A, Salati M, Marasco RD, Fianchini A. Inability to perform maximal stair climbing test before lung resection: a propensity score analysis on early outcome. Eur J Cardiothorac Surg. 2005;27:367-72.

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