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Original Research Article

6 Minute Walk Test Performance to Predict Postoperative Pulmonary Complications in Major Oncosurgeries

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Abstract

Postoperative pulmonary complications (PPCs) are a major cause of perioperative morbidity, mortality and longer hospital stays. Certain tests(6-minute walk test) can be performed preoperatively to predict the risk of postoperative pulmonary complications.

Aims and Objectives: To correlate 6-minute walk distance as a predictor of Postoperative Pulmonary Complications

Material and Methods: This prospective observational study, entitled "Performance of 6 minute walk test to predict postoperative pulmonary complications. The test was conducted as per American Thoracic Society (ATS) guidelines. Patients were encouraged to move at their normal pace and were given the option of pausing in between, on exhaustion while the timer was kept running. As the set time (6 minutes) elapsed, the patients were instructed to stop. Post-test hemodynamic parameters viz., blood pressure, heart rate, oxygen saturation were recorded. Level of dyspnoea was noted by asking them to mark it on the BORG scale[22], compared to the pre-test dyspnoea level. Finally, the laps were counted and the total distance covered (6 MWD) calculated. Group 1 (No Postoperative Pulmonary Complications) and Group 2 (Postoperative Pulmonary Complications).

Results: We observe that 6 minute walk distance for group 1 was significantly smaller compared to 6 minute walk distance for group 2 (423.4 vs 314.1) meters. Evidently, with a p-value of <0.001*, the difference between the groups was highly significant. The assessment of various risk factors for postoperative pulmonary complications (PPC) revealed that pre-test SPo2 < 96, 6MWD ≤ 328, FEV1 < 75 and FVC < 78 are the significant risk factors associated with PPC.

Conclusion: In clinically high risk patients undergoing elective oncosurgeries, the preoperative 6MWT is an easy, safe and feasible test for routine preoperative evaluation and may predict patients with a higher likelihood of developing PPC.

Keywords: Postoperative pulmonary complications, 6-minute walk test, Oncosurgeries

Introduction

Malignancies are the second leading cause of death globally, accounting for an estimated 9.6 million deaths in 2018[1]. Lung, prostate, colorectal, stomach and liver cancer are the most common types in men while breast, colorectal, lung, cervical and thyroid are most common malignancies among women[1]. The increasing incidence of malignancies worldwide and their detrimental effects has

led to an increasing interest in discovering new curative and preventive strategies.

Nevertheless, the major complications associated with such procedures, intra-operatively and postoperatively cannot be overlooked. These include: A) Systemic Complications: like pulmonary, cardiovascular, thromboembolic events and allergic reactions (B) Wound Related Complications like hematoma, seroma, infections etc. Among these, postoperative pulmonary complications (PPCs) are a major cause of perioperative morbidity, mortality and longer hospital stays. They occur in 5-10% patients, undergoing non-thoracic surgeries and 22% of patients undergoing thoracic surgeries. Even in minor surgeries, incidence can be 1-2%2. As many as 1 in 4 deaths occurring within a week of surgery is related to postoperative pulmonary complications (PPCs), thus making it the second most common serious morbidity after cardiovascular event[3]. Overall incidence of postoperative pulmonary complications (PPCs) varies between 2-40%[4].

Postoperative Pulmonary Complications include atelectasis, leading to postoperative hypoxemia (commonest complication), pneumonia, bronchitis bronchospasm, exacerbation of previous lung disease, pulmonary collapse due to mucous plugging of airways, respiratory failure with ventilatory support >48 hours, acute lung injury (ALI) including aspiration pneumonitis, transfusion related acute lung injury (TRALI), acute respiratory distress syndrome (ARDS) and pulmonary embolism.

Risk Factors of Postoperative Pulmonary Complications (PPCs) include: Preoperative (patient related) risk factors[7-12], like age >65 years, positive cough test, smoking, COPD, bronchial asthma, obesity, obstructive sleep apnoea (OSA), general health status (ASA >2, albumin <3.5 g%, poor functional status and reduced exercise capacity, and B) Intraoperative factors (Procedure-related)[8-17], like duration of surgery, site of surgery, type of surgery, type of anesthesia, blood transfusion, nasogastric tube (NGT), mechanical ventilation >48 hours.

Among the field tests, 6-minute walk test stands distinguished as it's simple, non-invasive, inexpensive with minimum technological requirement and has broad practical applications for the objective valuation of submaximal functional exercise capacity. It evaluates the global and integrated responses of all the body systems involved during the exercise, including the pulmonary and cardiovascular systems, systemic circulation, peripheral circulation, blood, neuromuscular units, and muscle metabolism[18].

As per American Thoracic Society (ATS) guidelines, absolute contra-indications for the 6-minute walk test include the following: unstable angina during the previous month and myocardial infarction during the previous month; relative contraindications include a resting heart rate of more than 120, a systolic blood pressure of more than 180 mmHg, and a diastolic blood pressure of more than 100 mmHg. Patients with any of these findings should be referred to the physician ordering or supervising the test for individual clinical assessment and a decision about the conduct of the test. The results from a resting electrocardiogram done during the previous 6 months should also be reviewed before testing. Stable exertional angina is not an absolute contraindication for a 6-minute walk test but patients with these symptoms should perform the test after using their anti-angina medication, and rescue nitrate medication should be readily available[19].

Various studies have shown that, 6-minute walk test is valid and reproducible and demonstrates a high positive association between 6-minute walk distance of <427m and VO2max of <11ml O2/kg/min in patients with cardiopulmonary diseases20.

Conversely, a study by Passani and colleagues in 2012 found no correlation between preoperative 6MWD and Postoperative Pulmonary Complications risk in patients who underwent upper abdominal surgeries[21].

Aims and Objectives

Primary Objective:

- To correlate 6-minute walk distance as a predictor of Postoperative Pulmonary Complications

Secondary Objectives:

- To find association of 6-minute walk distance with length of hospital stay.
- To find association of postoperative pulmonary complications (PPC) with risk factors like smoking, pulmonary function test (PFT) findings as well as with variations in hemodynamic parameters like blood pressure (BP), heart rate (HR) and oxygen saturation (SpO_2).

Material and Methods

This prospective observational study, entitled "Performance of 6 minute walk test to predict postoperative pulmonary complications" was conducted at the Sher-i- Kashmir Institute of Medical Sciences (SKIMS), Srinagar over a period of 2 years, from 2020 to 2022. Institutional ethical clearance was sought prior to the start of study. Study population included all patients undergoing elective thoracic or abdominal surgeries like esophagectomy, pulmonary lobectomy, mediastinal resections, gastrectomy, pancreaticobiliary resections, colectomies and ovarian cancer surgeries of probable duration ≥3 h under general anesthesia at Sher-i-Kashmir Institute of Medical Sciences (SKIMS).

Inclusion criteria:

- History of cardiovascular or pulmonary diseases
- Chronic smoker
- Chest X- ray with abnormal lung parenchymal/ chest wall findings.
- ASA class II and III

Exclusion criteria:

- Patients who had unstable angina/myocardial infarction/acute coronary syndrome in the previous 6 months
- Dyspnea at rest
- Inability to walk (orthopedic problems, cerebrovascular accidents, balance disorders)
- Severe pain
- Inability to interpret or follow instructions
- Resting tachycardia (HR ≥120 beats per min)/ uncontrolled hypertension (BP ≥180/100 mm of Hg).

As per the institutional protocol, all patients underwent the routine pre-operative evaluation. Patients who satisfied the inclusion criteria were selected and explained about the test procedure. So, the patients willing for the test were subjected to it only after obtaining well informed written consent from them. The test was conducted as per American Thoracic Society (ATS) guidelines[19], in the corridor of surgical oncology ward block as under:

Equipment's used were a countdown timer, a mechanical lap counter, two small cones to mark the turnaround points, an oxygen cylinder, a sphygmomanometer, a pulse oximeter, an automatic electronic defibrillator, a portable chair. After proper preparation as per ATS guidelines[19], the patients were made to sit relaxed in a chair at the starting point, for at least 10 minutes before the start of the test during which measurements of blood pressure (BP), heart rate (HR) and pulse oximetry (SpO_2) were recorded, and proper fitting comfortable clothing and shoes were ensured. Then they were made to stand and rate their baseline dypnoea and overall fatigue using the Borg scale[22].

They were encouraged to move at their normal pace and were given the option of pausing in between, on exhaustion while

the timer was kept running. The reason of stopping was mentioned in the record. As the set time (6 minutes) elapsed, the patients were instructed to stop. Post-test hemodynamic parameters viz., blood pressure, heart rate, oxygen saturation were recorded. Level of dyspnoea was noted by asking them to mark it on the BORG scale[22], compared to the pre-test dyspnoea level. Finally, the laps were counted and the total distance covered (6 MWD) calculated. With the completion of the test, they were congratulated on good effort and offered a drink of water.

Group 1 (No Postoperative Pulmonary Complications) and Group 2 (Postoperative Pulmonary Complications). Student's independent t-test or Mann-Whitney U-test, whichever feasible, was employed for comparing continuous variables. Chi-square test or Fisher's exact test, whichever appropriate, was applied for comparing categorical variables.

Results

We observe that the average age of group 1 patients was (56.4±9.43) years and the average age of group 2 patients was (58.3±10.17) years; however, with a p-value of 0.406, the difference in average of patients was statistically insignificant between the groups. We observe that 53.5% patients in group 1 were males compared to 46.5% females and in group 2, there were 56.3 male patients compared to43.8% females. Evidently, there was a predominance of male patients in both the groups; however, with a p-value of 0.812, the difference in gender distribution between the groups was comparable. We observe that majority of patients in both the groups had ASA II status, accounting for 88.4% in group 1 and 84.4% in group 2. With a p-value of 0.614, the difference between the groups was insignificant with respect ASA classification. We observe that average FEV1 (% predicted) in group 1 was (81.5±11.73) compared to (68.4±8.19) in group 2, and the average FVC (% predicted) in group 1 was (84.1±10.92) compared to (73.8±9.38) in group 2. Evidently the average FEV1 and FVC were significantly higher in group 1 compared to group 2.

When the comparison on the basis of pre-test vitals in the two groups was made, we found that mean pre-test SBP, mean pre-test DBP and mean pre-test HR were significantly smaller in group 1 compared to group 2. However, mean pre-test SPo2 was significantly smaller in group 2 compared to group 1. We observe that 6 minute walk distance for group 1 was significantly smaller compared to 6 minute walk distance for group 2 (423.4 vs 314.1) meters. Evidently, with a p-value of <0.001*, the difference between the groups was highly significant. We observe that mean level of post-test SBP, post-test DBP and post-test HR were significantly higher in group 2 compared to group 1. However; post-test SPo2 was significantly smaller in group 2 compared to group 1. We observe that mean post-test BORG dyspnea score [34] was significantly higher in group 2 compared to group 1 (8.71±1.94 vs 6.53±1.53; p-value<0.0001*). We observe that mean postoperative hospital stay in group 2 was higher in comparison to group 1 (15.4±3.57 vs 4.7±2.19) and the difference was statistically significant with a p-value of<0.0001*.

The assessment of various risk factors for postoperative pulmonary complications (PPC) revealed that pre-test SPo2 < 96, 6MWD ≤ 328, FEV1 < 75 and FVC < 78 are the significant risk factors associated with PPC. The multivariate analysis of significant risk factors for PPC revealed that 6MWD≤ 328 and FEV1 <75 are the precise predictors for the development of PPC.

Discussion

We observed that out of 75 patients; 32 developed PPC (group 1) and 43 patients did not develop PPC (group 2), thus placing the incidence rate of PPC as 42.66%, which is comparable with 46.66%

reported by Sathyaprasad, et al[23], Ozdilekcan et al[24] conducted a study to determine the incidence of different postoperative pulmonary complications (PPCs) and their associated risk factors in patients who have undergone various elective surgical procedures in an oncological surgery center. They reported the incidence rate of PPC as 40% (38/95), which is comparable with our study. Depending on definition, severity (from atelectasis to acute respiratory distress syndrome), and the existence of risk factors, PPC occurrence have been reported to range from 6% to 80%[25-29]. Postoperative pulmonary complications (PPCs), are the most prevalent complication affecting the respiratory system after anesthesia and surgery. Even mild PPCs can increase early postoperative mortality, the intensive care unit (ICU) admission rate and lengthen the duration of hospitalization.

Spirometry is a typical, simple, and non-invasive lung function test and is useful for identifying obstructive or restrictive ventilatory abnormalities in addition to the determination of the forced expiratory volume in 1 second (FEV1) and forced vital capacity (FVC). In the present study, we observed that average FEV1 (% predicted) in group 1 was (81.5±11.73) compared to (68.4±8.19) in group 2, and the average FVC (% predicted) in group 1 was (84.1±10.92) compared to (73.8±9.38) in group 2. Evidently the smaller average values for FEV1 and FVC were significantly correlated with higher likelihood of PPC. This is consistent with the study conducted by Stanzani et al[30] who found that smaller FEV1 and FVC strongly correlate with greaterrates of PPC. Similar to our study, Tajima et al[31] in their study reported that FVC (%) findings of preoperative spirometry tests were useful for predicting the development of postoperative pneumonia in patients who underwent colorectal surgery. In a different study, regular preoperative spirometry examinations helped to predict PPC occurrence in obese individuals after bariatric surgery. In contrast to these findings, Huh et al. showed that preoperative spirometry measurements could not be utilized to stratify the risk of PPC in elderly patients following laparoscopic gastrectomy[32]. These contradictory findings may be attributed to the fact that PPC is influenced by a number of variables, including the type of surgery, surgical site (upper or lower abdomen), intraoperative ventilator care strategy, postoperative lung care strategy, and other patient characteristics.[4]

When the comparison on the basis of pre-test vitals in the two groups was made, we found that mean pre-test SBP, mean pre-test DBP and mean pre-test HR were significantly higher in group 2 compared to group 1. However, mean pre-test spO2 was significantly smaller in group 2 compared to group 1. To the best of our knowledge, there are no studies that have determined the association between pretest vitals and the development of PPC. However, in one of the study by Sathyaprasad, et al[23] the authors found that patients with PPC had higher pretest SBP, DBP, HR and lower SPO2, which is compatible with our study.

The 6MWD test is a practical, simple, and easy to perform tool that provides a global assessment of pulmonary functional capacity. It is also used for pre- and postoperative evaluations in lung transplantation and lung volume reduction surgery.[33] In addition, 6MWT is used to monitor the response to therapy and to predict the mortality and morbidity of patients with chronic respiratory disease like idiopathic pulmonary fibrosis, pulmonary artery, hypertension, and COPD[34]. We performed the 6-minute walk test in a 25- meter-long flat corridor in surgical oncology surgery ward block, where emergency help, a defibrillator, and an emergency cart were all readily available. In accordance with ATS recommendations[19], we employed a

stopwatch, measuring tape, portable pulse oximetry probe, sphygmomanometer, and lap counter. The test was halted if the patient suffered any chest discomfort, extreme dyspnea, leg cramps, diaphoresis, or a pallid or lifeless look, and medical attention was sought. We observed that 6 minute walk distance for group 1 was significantly longer compared to 6 minute walk distance for group 2 (423.4 vs 314.1) meters. Evidently, with a p-value of <0.001*, the difference between the groups was highly significant. Likewise to our study, majority of studies have reported a significant association of 6MWD with PPC. During the 6MWT, Santos et al reported that the group without PPC in the postoperative period walked 422.38 metres compared to 340.89 (SD=100.93) metres for the PPC group and much similar to our study, they reported a significant association of 6MWD with PPC[35]. In their study, Sathyaprasad et al. found that 6-minute walk distance of patients who acquired PPC was considerably less than that of patients without PPC (344 61.927 m vs 442.28 83.194 m; P value = 0.001), which is consistent with our findings[23].

In the present study, the post-test haemodynamic parameters reflecteda significant increase in SBP (145.13 mmHg vs 131.52mmHg, p<0.001), DBP (87.93 mmHg vs 81.07mmHg, p<0.001) and HR (104.81 vs 92.39 mmHg, p<0.001) between the two groups but post-test SpO2 was significantly smaller in group 2 compared to group 1(94.72 vs 97.4). In a likewise study by Sathyaprasad, et al[23] the post-test haemodynamic parameters also showed a significant variation in systolic BP (140.51 ± 15.252 Vs 130.3 ± 15.875, P = 0.006), HR (103.74 ± 16.227 Vs 90.53 ± 16.339, P = 0.001) and SPo2 (94.97 vs 97.63, p<0.001) between the two groups, these findings are consistent with our study.

The primary symptom that people with chronic respiratory illnesses notice is dyspnea. It results from a complex combination of impulses coming from the central nervous system, which is linked to the peripheral respiratory system via afferent route receptors (airways, lung, and thorax). There are many scales available today to categorize and describe dyspnea, but Borg dyspnoea scale[22] has been exploited by a good corpus of scholars due to its high efficiency. In the present study, we observed that mean post-test BORG dyspnea score was significantly higher among patients who developed PPC in comparison to those who did not develop PPC (8.71±1.94 vs 6.53±1.53; p-value<0.0001*). This is compatible with the results reported by Sathyaprasad, et al.[23] who also found higher post-test BORG dyspnea score in patients who developed PPC. In agreement with our results, Prajapati et al in their study also reported higher BORG dyspnea scores were significantly associated with PPC[36].

Postoperative pulmonary complications contribute significantly to morbidity, mortality and length of hospital stay. Evidently, the mean postoperative hospital stay for group 2 patients was higher in comparison to group1patients (15.4±3.57 vs 4.7±2.19) and the difference was statistically significant with a p-value of<0.0001*. Much similar to this; Lawrence et al in their study reported that the postoperative pulmonary complications significantly contribute to lengthy duration of hospital stay[37]. In fact, Sathyaprasad, et al, Ambrosino et al and Agostini et al, reported in their study that shorter 6MWD was significantly correlated with longer hospital stay of patients, which corroborates with our results because patients who developed PPC had shorter 6MWD compared to those who did not develop PPC[23,38,39]. Awdeh and colleagues recently demonstrated in a prospective analysis of 117 patients undergoing major surgery in 2015 that a preoperative 6MWD of less than 300 m was related to postoperative LOS and

various categories of PPC (atelectasis, pneumonia, and extended MV)[40]. The risk of PPC was not associated with preoperative 6MWD in patients who underwent upper abdominal surgery (UAS), according to a study by Paisani and colleagues, the reason might be attributed to the heterogenic ethnicity and varying study designs[21]. The comprehensive univariate analysis demonstrated that pre-test SPo2 < 96%, 6MWD ≤ 328metres, FEV1 < 75% and FVC < 78% were the significant risk factors associated with PPC. However; after a logistic multivariate regression analysis, the odds ratio for (spo2<96%) and (FVC <78%) was low 1.53 and 1.83 respectively, with the result the 6MWD and FEV1 < 75 happened to be the only significant independent predictors of PPC. Evidently, the 6MWT had an equal performance in PPC prediction to FEV1% predicted, but was significantly better than FVC% predicted by spirometry test. The ROC analysis revealed that with a sensitivity, specificity, and diagnostic accuracy of 78.3%, 97.2% and 86.5% respectively, the optimal cutoff for predicting the postoperative pulmonary complications was 6MWD ≤328m. Patients with a 6MWD ≤ 300 m were shown to be more likely to experience postoperative pulmonary problems in a study by Ambrosino et al, which is comparable with our study[38]. In another study by Agostini et al, the authors reported that 6MWD of less than 400 m was frequently associated with PPC and an extended hospital stay[39].Pancieri et al in their studyreported that in patients with heart failure, when the 6MWD was 300 meters or less, the risk of developing PPC increased, which is in agreement with our study[41]. Keeratichananout et al, reported in their study that a cutoff value of 6-minute walk distance of less than 325 metres exhibited a sensitivity of 77% and a specificity of 100% for the prediction of a post-operative cardiac problems, which is in harmony with our study[42]. The 6MWD trend for PPC prediction in the present study was comparable to that in the study conducted by Awdeh and colleagues, but the cutoff level was different, possibly as a result of the varied definitions of the primary outcome of interest and the diverse ethnic groups[40]. Paisani and colleagues, however, showed no correlation between preoperative 6MWD and the PPC risk in patients who underwent UAS[21]. These seemingly contradictory outcomes might have a number of causes. One of them being the heterogenic patient population with varying degree of preoperative pulmonary function impairment and the others might include different set of definitions adopted in different studies.

Conclusion

In the present study, the assessment of various risk factors for postoperative pulmonary complications (PPC) revealed that pre-test SPo2 < 96, 6MWD ≤ 328, FEV1 < 75 and FVC <78 are the significant risk factors associated with PPC. However; multivariate logistic analysis demonstrated that the precise independent significant predictors for the development of PPC are 6MWD and FEV1<75. With a sensitivity of 97.2%, the optimal cut off value for predicting the postoperative pulmonary complications among patients with elected oncosurgeries was 6MWD ≤328. In clinically high risk patients undergoing elective oncosurgeries, the preoperative 6MWT is an easy, safe and feasible test for routine preoperative evaluation and may predict patients with a higher likelihood of developing PPC.

References

1. World Health Organisation; 2018 September
2. Kelkar KV. Post-operative pulmonary complications after non-cardiothoracic surgery. Indian J Anaesth. 2015;59(9):599-605
3. Fischer SP, Bader AM, Sweitzer BJ. Miller's Anaesthesia. 7th ed. Ch. 34. New York: Churchill Livingstone;

2010. Preoperative evaluation; pp. 1019–22.
4. Rock P, Rich PB. Postoperative pulmonary complications. Curr Opin Anaesthesiol. 2003; 16:123–31.
5. Arozullah AM, Khuri SF, Henderson WG, Daley J. Participants in the National Veterans Affairs Surgical Quality Improvement Program. Development and validation of a multifactorial risk index for predicting postoperative pneumonia after major noncardiac surgery. Ann Intern Med. 2001; 135: 847–57.
6. Shander A. Managing postoperative pulmonary complications. Physicians Wkly. 2012. Jun 5, [Last accessed on 2015 Jul 12].
7. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: A new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg. 2004; 240:205–13.
8. Choudhuri AH, Chandra S, Aggarwal G, Uppal R. Predictors of postoperative pulmonary complications after liver resection: Results from a tertiary care intensive care unit. Indian J Crit Care Med. 2014; 18:358–62.
9. Roizen MF, Fleisher LA. Anaesthetic implications of concurrent disease. In: Miller R, editor. Miller's Anaesthesia. 7th ed. Ch. 35. New York: Churchill Livingstone; 2010. pp. 1103 11.
10. McAlister FA, Bertsch K, Man J, Bradley J, Jacka M. Incidence of and risk factors for pulmonary complications after nonthoracic surgery. Am J Respir Crit Care Med. 2005; 171:514–7.
11. Toori KU, Khan JS, Nomani AZ, Hussain SW, Hashmi S. A prospective study of factors predicting PPC in patients undergoing non cardiothoracic surgery under general anaesthesia in developing country. Anaesth Pain Intensive Care. 2012; 16:252–6.
12. Mark A. William A. Schwer., editor. Yoder, Sat Sharma. Medscape - Perioperative pulmonary management: e-medicine. Medscape.com/ marticle 284983.
13. Smetna G. Preoperative pulmonary evaluation – Current concepts – A review article. N Engl J Med. 1999; 340:937–44.
14. Milner A. Reducing postoperative pulmonary complications in non-cardiothoracic surgery patients. South Afr J Anaesth Analg. 2011; 17:27–30.
15. Canet J, Mazo V. Postoperative pulmonary complications. Minerva Anestesiol. 2010; 76:138–43.
16. Grooms DA. Postoperative Pulmonary Complications. Clinical Foundations– A Patient Focussed Evaluation Program for Respiratory Care Professionals. 2012.
17. Lawrence VA, Cornell JE, Smetana GW. American College of Physicians. Strategies to reduce postoperative pulmonary complications after noncardiothoracic surgery: Systematic review for the American College of Physicians. Ann Intern Med. 2006; 144:596–608.
18. Morales-Blanhir et al. 2011; American Thoracic Society, 2002; Solway et al. 2001; Butland et al. 1982.
19. American Journal of Respiratory and Critical Care Medicine; 2002 July; 166(1); 111-17.
20. Casillas et al. 2013; Lee et al. 2013; Sinclair et al. 2012; Guimarães et al. 2008; Knox et al. 1998.
21. Paisani DM, Fiore JF Jr, Lunardi AC, Colluci DB, Santoro IL, Carvalho CR, Chiavegato LD, Faresin SM. Preoperative 6-min walking distance does not predict pulmonary complications in upper abdominal surgery. Respirology. 2012 Aug;17(6):1013-7.
22. Borg GA. Psychophysical bases of perceived exertion. Med Sci Sports Exerc 1982; 14:377-81.
23. Sathyaprasad SL, Thomas M, Philip FA, Krishna KJ. Performance in 6-min walk test in prediction of post-

operative pulmonary complication in major oncosurgeries: A prospective observational study. Indian J Anaesth. 2020 Jan;64(1):55-61.
24. Ozdilekcan C, Songur N, Berktaş BM, Dinç M, Uçgül E, Ok U. Risk factors associated with postoperative pulmonary complications following oncological surgery. Tuberk Toraks. 2004;52(3):248-55.
25. Canet J, Gallart L, Gomar C, et al; ARISCAT Group. Prediction of postoperative pulmonary complications in a population-based surgical cohort. Anesthesiology. 2010;113(6):1338-50.
26. Arozullah AM, Daley J, Henderson WG, Khuri SF; The National Veterans Administration Surgical Quality Improvement Program. Multifactorial risk index for predicting postoperative respiratory failure in men after major noncardiac surgery. Ann Surg. 2000; 232(2):242-53.
27. Ferreyra GP, Baussano I, Squadrone V, et al. Continuous positive airway pressure for treatment of respiratory complications after abdominal surgery: a systematic review and meta-analysis. Ann Surg. 2008;247(4):617-26.
28. Fagevik Olsén M, Hahn I, Nordgren S, Lönroth H, Lundholm K. Randomized controlled trial of prophylactic chest physiotherapy in major abdominal surgery. Br J Surg. 1997;84(11):1535-38.
29. Celli BR, Rodriguez KS, Snider GL. A controlled trial of intermittent positive pressure breathing, incentive spirometry, and deep breathing exercises in preventing pulmonary complications after abdominal surgery. Am Rev Respir Dis. 1984;130(1): 12-15.
30. Tajima Y, Tsuruta M, Yahagi M, Hasegawa H, Okabayashi K, Shigeta K, et al. Is preoperative spirometry a predictive marker for postoperative complications after colorectal cancer surgery? Jpn J Clin Oncol. 2017; 47(9):815–9.
31. Clavellina-Gaytan D, Velazquez-Fernandez D, Del-Villar E, Dominguez- Cherit G, Sanchez H, Mosti M, et al. Evaluation of spirometric testing as a routine preoperative assessment in patients undergoing bariatric surgery. Obes Surg. 2015; 25(3):530–6.
32. Huh J, Sohn TS, Kim JK, Yoo YK, Kim DK. Is routine preoperative spirometry necessary in elderly patients undergoing laparoscopy-assisted gastrectomy? J Int Med Res. 2013; 41(4):1301–9.
33. Kundu A, Maji A, Sarkar S, Saha K, Jash D, Maikap M. Correlation of six minute walk test with spirometric indices in chronic obstructive pulmonary disease patients: A tertiary care hospital experience. J Assoc Chest Physicians. 2015; 3:9-13.
34. Miller MR, Crapo R, Hankinson J, Brusasco V, Burgos F, Casaburi R, et al.; ATS/ERS Task Force. General considerations for lung function Testing. EurRespir J. 2005;26: 153-61.
35. Santos BF, Souza HC, Miranda AP, Cipriano FG, Gastaldi AC. Performance in the 6-minute walk test and postoperative pulmonary complications in pulmonary surgery: an observational study. Braz J Phys Ther. 2016 Jan- Feb;20(1):66-72.
36. Prajapati PP, Mehta PH, Aghara A, Mehta KH. Six minute walk test for predicting postoperative pulmonary complications in high risk patients undergoing major abdominal elective surgery. Indian J Clin Anaesth. 2021;8(3):418-421.
37. Lawrence VA; Dhanda R; Hilsenbeck SG; Risk of pulmonary complications after elective abdominal surgery Chest. 1996 Sep;110(3):744-50.
38. Ambrosino N, Bruschi C, Callegari G, Baiocchi S, Felicetti G, Fracchia C, et al. Time course of exercise capacity, skeletal and respiratory muscle performance after heart-lung

transplantation. Eur Respir J. 1996; 9:1508-14.
39. Agostini P, Cieslik H, Rathinam S, Bishay E, Kalkat MS, Rajesh PB, et al. Postoperative pulmonary complications following thoracic surgery: Are there any modifiable risk 36. factors? Thorax. 2010;65: 815-8.
40. Awdeh H, Kassak K, Sfeir P, Hatoum H, Bitar H, Husari A. The SF-36 and 6-minute walk test are significant predictors of complications after major surgery. World J Surg 2015; 39:1406-12.
41. Pancieri MV, Cataneo DC, Montovani JC, Cataneo AJ. Comparison between actual and predicted postoperative stair-climbing test, walk test and spirometric values in patients undergoing lung resection. Acta Cir Bras. 2010;25(6):535-40.
42. Keeratichananont W, Thanadetsuntorn C, Keeratichananont S. Value of preoperative 6-minute walk test for predicting postoperative pulmonary complications. Ther Adv Respir Dis. 2016; 10:18-25.