

Preoperative incremental shuttle walk test for morbidity and mortality prediction in elective major colorectal surgery

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ABSTRACT

Background and Aims: The incremental shuttle walk test (ISWT) is a simple reproducible and non-invasive test for assessing cardiopulmonary function. The maximum oxygen consumption is less than 10 ml/kg/min for ISWT distance of less than 250 m. This study aimed to evaluate the effectiveness of ISWT in predicting morbidity and mortality in elective colorectal oncosurgery and to find the correlation of ISWT with the Duke Activity Status Index (DASI), Borg dyspnoea score, and peak oxygen uptake (VO₂ max). **Methods:** This prospective study involved 46 patients aged more than 60 years with American Society of Anesthesiologists physical status I and II undergoing elective colorectal surgery under general anaesthesia with an epidural block. ISWT was conducted preoperatively and patients were monitored for 30 days postoperatively. For a comparative analysis, patients were divided into two groups: group 1 – who could walk 250 m and group 2 – could not walk 250m. Categorical data were evaluated using the Chi-square test, while continuous data were evaluated using the Student's *t*-test. The strength of correlation was determined using Pearson's correlation coefficient. **Results:** Postoperative complications ($P = 0.001$) and lengthy stay in hospital and intensive care unit ($P = 0.001$) were experienced by all patients who were unable to complete the ISWT distance of 250 m. ISWT distance of 250 m corresponds to a DASI score of 10.5, which is equivalent to a calculated VO₂ max of 14.1ml/kg/min. **Conclusion:** The ISWT with a cutoff distance of 250 m is a reliable predictor of postoperative morbidity in patients undergoing colorectal oncosurgery.

Key words: Colorectal surgery, morbidity, postoperative complication, preoperative care, walk test

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INTRODUCTION

Oxygen consumption increases in the postoperative period up to 50%.^[1] Patients who cannot match this metabolic demand are more likely to experience postoperative complications.^[1,2] Preoperative assessment of cardiopulmonary reserve is recommended to assess functional capacity. The incremental shuttle walk test (ISWT) that is non-invasive, cost-effective, simple to perform, and strongly corresponds to peak oxygen uptake (VO₂ max) during cardiopulmonary exercise testing (CPET) on a treadmill was chosen over the other tests.^[3,4] The primary objective of this study was to evaluate the effectiveness of the ISWT in predicting morbidity and mortality in elective colorectal surgery. Secondary

objectives were to find the correlation of ISWT with the Duke Activity Status Index (DASI) and VO₂ max.

METHODS

This cross-sectional study was performed on 46 patients who underwent major elective colorectal

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surgery under general anaesthesia with an epidural block in a tertiary care cancer centre between January and December 2018. Before beginning the study, institutional review board (IRB NO: 10/2017/14) and hospital ethics committee (HEC NO: 31/2017) approval were obtained.

The study population included all patients aged more than 60 years of American Society of Anesthesiologists (ASA) physical status I and II undergoing colorectal oncosurgery under general anaesthesia with an epidural block with any one of the following criteria: well-controlled diabetes mellitus, hypertension, and mild lung disease. The exclusion criteria were failure to give consent, body mass index (BMI) more than 40, coronary artery disease within the previous 6 months, breathlessness at rest, walking difficulty, acute or chronic pain, chronic smoking, and inability to follow the given instructions. According to the institutional protocol, all enrolled patients underwent routine pre-anaesthesia evaluation that included history taking, physical examination, laboratory investigations, basic electrocardiogram (ECG), and spirometry (if indicated). The patients who fit the requirements for inclusion were selected, the testing procedure was explained, and informed written consent was obtained. Before the shuttle walk test, 46 patients completed the chronic respiratory disease questionnaire to assess health-related quality of life and DASI to measure functional status based on various physical activities [Table 1].^[5]

Table 1: Duke Activity Status Index^[5]

	Yes	No
Can you take care of yourself (eating, dressing, and bathing)?	2.75	0
Can you walk indoors, such as around your house?	1.75	0
Can you walk a block or two on level ground?	2.75	0
Can you climb a flight of stairs or walk up a hill?	5.50	0
Can you run a short distance?	8.00	0
Can you do light work around the house, such as dusting or washing dishes?	2.70	0
Can you do moderate work around the house, such as sweeping floors or carrying in groceries?	3.50	0
Can you do heavy work around the house, such as scrubbing floors or lifting and moving heavy furniture?	8.00	0
Can you do yard work, such as raking leaves, weeding, or pushing a power mower?	4.50	0
Can you have a sexual relation?	5.25	0
Can you participate in moderate recreational activities, such as golf, bowling, dancing, doubles tennis or throwing a baseball, or football?	6.00	0
Can you participate in strenuous sports, such as swimming, singles tennis, football, or basketball?	7.50	0

DASI=Sum of "Yes" replies, peak oxygen uptake (VO₂ max)=(0.43×DASI)+9.6

The test was conducted in a 25-m long, flat, and straight hallway near the surgical ward where there was a telephone, a defibrillator, and access to oxygen and a code blue (cardiac arrest) team that could be activated in case of an emergency. The ISWT was done under the guidance of the first investigator who was an advanced cardiac life support trained person. The patient walked around two cones that were 9 m apart, covering a total distance of 10 m for each shuttle [Figure 1]. The patients were instructed to increase their speed of walking such that they covered three shuttles (30 m) at the first level, four shuttles (40 m) at level 2, and so on.^[6,7] There were 12 progressive levels altogether, making the total distance covered at the end of 12th level 1020 m. Peripheral oxygen saturation and heart rate (HR) were monitored every minute using a portable Medline finger pulse oximeter that was light weight, gentle to touch, and easy to use.^[6,7] When the patient became breathless, too exhausted, or unable to maintain the required speed, the test was terminated.^[8] The recovery time, distance covered, the reason for the test having been stopped, and the Borg score that assesses the perceived exertion during activity on a scale of 6–20 were all documented. Scores of 6 indicate no effort at all and 20 indicate maximum exertion.^[9] Recovery time was the duration of time taken for all haemodynamic parameters to return to their initial value. Furthermore, the patients went through the surgery as scheduled under general anaesthesia with an epidural block. Additionally, they underwent routine standard postoperative care. All patients were followed up for a period of 30 days.^[10] The all-cause mortality in the first 30 days following the surgery was the main evaluation. The secondary evaluation was postoperative complications in 30 days, duration of hospital stay, duration of intensive care unit (ICU) stay, and whether patient needed any unplanned readmission within 30 days. A cutoff distance of 250m was taken to predict postoperative complications.^[10]

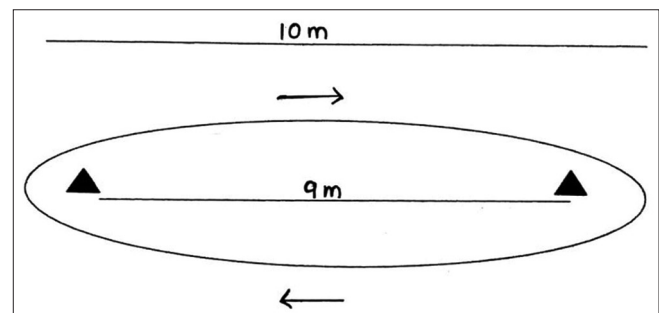


Figure 1: Shuttle walk distance

For analysis, patients were separated into two groups based on a cutoff distance of 250 m: group 1– able to walk more than 250 m and group 2– not able to walk 250 m. The postoperative complications that were looked for included surgical complications, such as bleeding, anastomotic leak, and wound infection, respiratory complications, such as pneumonia, acute respiratory distress syndrome, pneumothorax, and pulmonary embolism, cardiac events, such as myocardial infarction, cardiac arrhythmias, and cardiac failure, and other complications, such as stroke, urinary tract infection, and infections related to central venous line. All these were diagnosed based on blood, urine, and pus culture, respectively. For other complications, imaging studies, ECG, echocardiography, and blood tests were done and European Joint Taskforce Guidelines 2015, European Perioperative Clinical Outcome definitions were followed.^[10] The distance covered, vital parameters before and after the test, Borg score, length of hospital and ICU stay, and postoperative complications were compared between these groups.

Based on the study by Nutt and Russell,^[10] for the variable shuttle walk test distance, with 80% power, level of significance at 5% and using a two-sided test, the minimum sample size required for the present study was estimated at 43. The Statistical Package for the Social Sciences (SPSS) (International Business Machines) version 28.0 was used for statistical analysis. Finally, 46 patients were taken into consideration for the present study after taking attrition into account [Figure 2]. The mean and standard deviation represented continuous variables. Frequency and relative proportion were used to describe categorical variables. The Chi-square test was used to assess the significance between the two categorical variables. Because all the variables were normally distributed, the Student's *t*-test was used for continuous variables. The strength of association between DASI and distance walked as well as peak oxygen consumption and distance walked was determined using the Karl Pearson's correlation coefficient. P-value less than 0.05 was regarded as statistically significant.

RESULTS

The study was performed on 46 patients. Eighteen patients had diabetes mellitus, 20 patients had systemic hypertension, five had chronic obstructive pulmonary disease (COPD) and 28 patients underwent chemotherapy before the surgery.

All patients were able to finish the test without any complications. The average duration of the test was only 15 min. Among the study group, 26 patients (56.5%) were females and 20 patients (43.5%) were males. Both groups had similar duration of surgery. No significant difference was found for gender, whereas BMI was found to be significant between the groups. The mean BMI (22.74 ± 3.2) was lower among patients who walked more than 250 m ($P = 0.006$). Those who could walk more than 250 m of ISWT had a mean age of 64.21 ± 4.8 years. Additionally, it was shown that age of group 2 was much lower ($P = 0.001$). Out of 46 patients, 38 (82.6%) patients could walk more than a distance of 250 m. The average distance walked by group 1 patients was 197.5 m and group 2 was 600 m. Reasons for stopping the test were exhaustion and dyspnoea. Sixteen patients (34.8%) had postoperative complications, such as pneumonia (21.7%), acute respiratory distress syndrome (4.3%), and wound infection (8.6%). After surgery, every patient with an ISWT distance less than 250 m experienced a major complication, majority of which were pulmonary complications (P value = 0.001) [Figure 3]. Maximum desaturation was 93% with a maximum oxygen saturation fall from baseline by 3% following the test. The mean maximal HR was 81 beats per minute that was achieved by 52% of patients. Group 2 required longer time to recover (P value = 0.001) [Table 2].

Both the length of the hospital stay (11.75 ± 2.18 days versus 6.45 ± 1.42 days, $P = 0.001$) and the length of ICU stay (3.5 ± 1.6 versus 0.53 ± 0.83 days, $P = 0.001$) were considerably longer in group 2 than group 1. The patients who underwent the surgery were followed up for a month. On the 30th postoperative day, 76.1% were at home and 23.9% were readmitted to ward in a local hospital because of respiratory complications and wound infection.

Table 2: Comparison of parameters between the groups

Parameters	Group [†]	Mean	Standard deviation	P
Age in years	1	64.21	4.805	*0.001
	2	71.88	3.314	
BMI in kg/m ²	1	22.74	3.227	*0.006
	2	19.25	2.605	
Pre-test HR (beats per min)	1	74.42	5.525	*0.046
	2	69.63	8.105	
Post-test HR (beats per min)	1	82.05	5.412	0.093
	2	78.00	8.751	
Recovery Time in min	1	8.29	1.829	*0.001
	2	11.38	2.560	

HR=heart rate, BMI=body mass index. * $P < 0.05$, [†]group 1=walk >250m, group 2=walk <250m

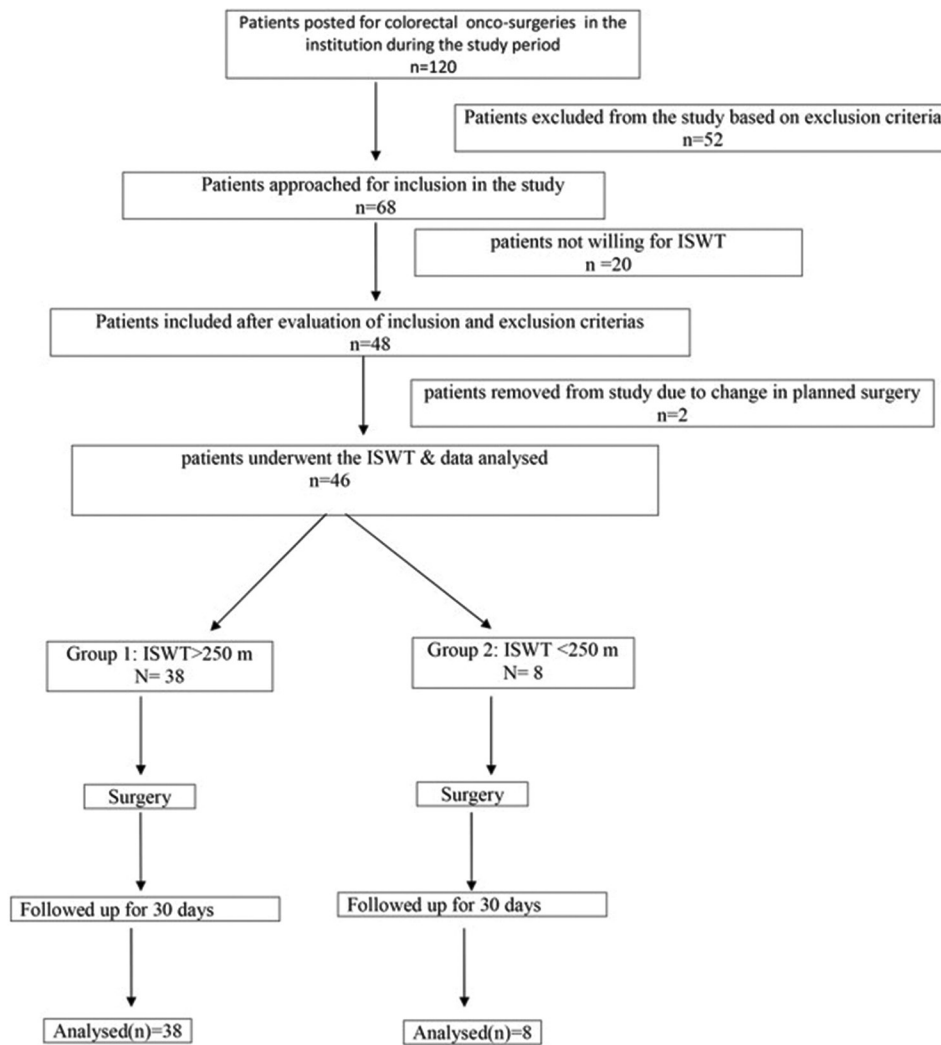


Figure 2: Schematic representation of selection of study population. ISWT: Incremental shuttle walk test

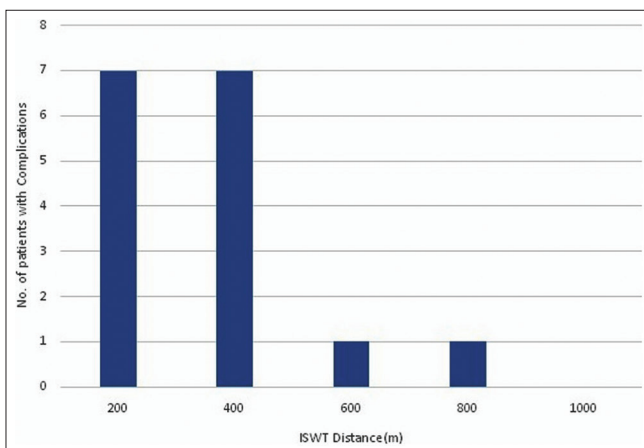


Figure 3: Number of patients having postoperative complications according to the incremental shuttle walk test distance covered

Each patient completed the DASI questionnaire before the test; the mean score was 23.04, which corresponds to a calculated VO_2 max of 19.5 ml/min. The mean

DASI for group 2 patients was 10.5, corresponding to a VO_2 max of 14.25 ml/kg/min versus 25.68 and 20.74 ml/kg/min for group 1. DASI and VO_2 max significantly varied between the two groups (P value 0.001). There was a sufficient degree of correlation between DASI and distance walked (coefficient of correlation 0.794) as well as VO_2 max and distance walked (coefficient of correlation 0.801; P -value 0.001) [Table 3].

DISCUSSION

The main factors contributing to postoperative morbidity and mortality are cardiopulmonary complications. Functional exercise capacity assessment preoperatively can detect patients who are more likely to experience complications after surgery and improves perioperative optimisation.^[10] The ISWT correlates better with measurement of anaerobic

Table 3: DASI, VO₂ max, and Borg score of study population

Parameters	Group ⁺	Mean	Standard deviation	P
DASI	1	25.68	7.847	*0.001
	2	10.50	4.375	
VO ₂ max in ml/kg/min	1	20.74	3.277	*0.001
	2	14.25	1.669	
Borg score	1	5.74	1.083	*0.022
	2	6.75	1.165	

DASI=Duke Activity Status Index, VO₂ max=peak oxygen uptake.
*P<0.05, †group 1=walk >250m, group 2=walk <250m

threshold acquired by CPET than time-limited non-maximal tests such as 6-min walk test (6 MWT) and stair-climbing test.^[11,12]

Oncosurgical patients are more likely to experience postoperative complications than general surgical patients because of the effects of malignancy, immunosuppression, chemotherapeutic drugs, radiotherapy, malnutrition, anaemia, and multiple co-morbidities.^[13,14] All 46 patients in the current study understood the ISWT procedure easily and were able to finish the test without any significant complications, demonstrating the safety and convenience of the test.

In a study on ISWT among colorectal surgical patients, the authors considered a cutoff distance of 250 m with a specificity of 88% and sensitivity of 58% to predict postoperative complications.^[10] This cutoff distance showed that patients who were unable to complete a distance of 250 m had a high risk of experiencing postoperative problems. For predicting postoperative morbidity and mortality following thoracic surgery, an ISWT cutoff value of 250 m has been advised.^[15] For lung cancer surgery, the patients who failed to achieve 250 m during a shuttle walk test had a 6% mortality rate and a 43% morbidity rate. A cutoff distance of 350 m was considered for oesophagectomy surgery.^[16] On literature search, we found that there were not many studies on ISWT in predicting the postoperative outcome in open colorectal cancer surgeries in the Indian sub-population. In our study, we took a cutoff distance of 250 m to assess the postoperative outcome. ISWT distance of less than 250 m correlates to maximal oxygen consumption of <10 ml/kg/min.^[17] There was a significant association between complication rates and shuttle walk distance. We found that postoperative complications were lesser in patients who could walk more than 250 m in ISWT.

The use of ISWT to anticipate postoperative complications has not been extensively studied. The literature is consistent with a significant correlation

of ISWT with postoperative complications.^[10,16] The occurrence of postoperative pulmonary complication ranges from 2 to 40% and mortality of 10%.^[18] There was no mortality in our study population. It might be because patients with ASA physical class more than II were excluded and the sample size was small. But all patients who were unable to complete 250 m had complications. We observed that pneumonia and wound infection were the most frequent postoperative complications in our study population. The higher prevalence of poor wound healing could be explained by the effects of chemotherapeutic drugs, poor nutritional status, and open type of surgery as well as the fact that a decreased functional reserve can result in compromised oxygen delivery to allow a normal wound-healing process.^[16] Poor wound healing can predispose to infection. Open surgery has more wound infection rates than laparoscopic surgery.^[19]

In our study, the majority of patients (76%) returned home after 30 days without any complications. Ninety percent of patients had returned home in another similar study because of lesser complications.^[10] The incidence of postoperative complications considerably lengthened the hospital stay (11.25 ± 2.18 , $P < 0.001$) and ICU stay (3.5 ± 1.6 , $P < 0.001$) in the affected group.

In our study, patients with low BMI were unable to perform well during the test. COPD patients with high BMI showed a low walking capacity.^[20] Extremes of BMI can affect the walking capacity.

HR and oxygen saturation before and during the test may reveal the underlying pathology. But in our study, the mean maximal HR was 81 beats per min, which was much lower than in other literature.^[10] As most of our study population were elderly, they could have had conduction system abnormalities associated with ageing and some of our hypertensive patients were on betablockers, and hence, their maximal HR could have been low.^[21] The mean oxygen saturation fell by 3% after walk. In conditions such as heart failure or ischaemia, a low ratio of VO₂/HR along with echocardiographic and ECG changes helps to identify cardio-circulatory limits.^[6,22]

Self-reported functional capacity was incorporated into preoperative risk evaluation with the help of DASI questionnaire.^[23] In our study, the mean DASI was lower for patients who were unable to complete 250 m. Lung resection candidates with preoperative

pulmonary exercise VO_2 max <15 ml/kg/min are more likely to have a poor outcome.^[24] Numerous studies have concluded that the patients with a preoperative VO_2 max >20 ml/kg/min are not at an increased risk of complications or mortality, and those with VO_2 max <10 ml/kg/min have a very high risk of postoperative complications.^[25] According to a different study, VO_2 predicted by DASI and ISWT had a reasonable correlation.^[26]

The mean Borg score was 5.91. The post-exercise Borg dyspnoea score was more in group 1 patients that is significantly associated with ISWT distance ($P = 0.022$). Patients with a high Borg dyspnoea score after 6MWT had more postoperative pulmonary complications.^[27]

A modified shuttle walk test has better physiological responses compared with 6MWT.^[27,28] ISWT carried out in a hallway and on a treadmill in healthy individuals revealed that the distance performed in the hallway was poor compared to the distance performed in a treadmill. But the physiological response was similar in both tests. However, values of ISWT performed in a hallway and on a treadmill are not compatible.^[29] There are some limitations to the study. Numerous non-cardiopulmonary characteristics, such as age, gender, height, and weight, can influence the performance of the study. Motivation is required throughout the test. We could not compare the ISWT with other exercise tests.

CONCLUSION

The ISWT is a simple, reproducible, non-invasive, and inexpensive predictor of postoperative complications in colorectal oncosurgery. The patients who are unable to complete a distance of 250 m have a higher chance of experiencing postoperative complications and a long duration of hospital and ICU stay. Peak oxygen consumption and distance walked are sufficiently correlated. Therefore, ISWT can predict the patients who have a higher postoperative risk.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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