Prognostic value of the 1-min sit-to-stand test to predict post-operative complications in patients with lung cancer elected for lung resection

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To the Editor:

Lung resection is the preferred curative treatment for early-stage nonsmall cell lung cancer (NSCLC) [1]. However, post-operative complications cannot be ruled out, particularly in patients with pre-existing cardiorespiratory impairment [2]. Therefore, evaluation of patients' pre-operative status is crucial in the evaluation of the risk of post-operative complications.

Pre-operative peak oxygen consumption (V'_{O_2peak}) measured by a cardiopulmonary exercise test (CPET) effectively identifies patients at moderate-to-high risk of post-operative complications [3], but its cost and complexity limit clinical applicability [4]. Alternatively, the 1-min sit-to-stand test (1MSTS) can be used, which is quick, requires minimal space and equipment, and stresses the cardiorespiratory system [5].

A recent single-centre study found a threshold of 20 repetitions on the 1MSTS to identify patients at risk of complications after lung resection, limiting its external validity [6]. The current multicentre study aimed to evaluate the ability of the 1MSTS to predict post-operative complications in patients with NSCLC undergoing lung resection *via* open thoracotomy or video-assisted thoracoscopic surgery (VATS).

This multicentre study was approved by the medical ethical committee of Hasselt University (Diepenbeek, Belgium), Ziekenhuis Oost-Limburg Genk (Genk, Belgium), Universitair Ziekenhuis Ghent (Ghent, Belgium), and the Knowledge Outcomes committee at Fiona Stanley Hospital (Perth, Australia; B3712020000002, March 2020), and was part of a larger observational trial (clinicaltrials.gov identifier NCT02493114). Data were partially presented during the European Respiratory Society congress [7]. Between August 2020 and April 2023, patients with NSCLC who were scheduled for lung resection in Belgium (Genk, Ghent) and Australia (Perth) were invited to participate in the study.

Exclusion criteria were a history of lung cancer; other malignancies in the past 2 years; progressive neuromuscular and neurological diseases; unstable cardiac disease; orthopaedic conditions that impaired functional status; and mental or psychiatric disorders that were likely to impair the ability to comply with study procedures. Eligible patients were identified during pre-operative appointments at the hospital, and all provided written informed consent.

The 1MSTS was performed pre-operatively using an armless chair (seat height 45 cm). Patients were instructed to rapidly stand and sit down with their arms crossed over their chest for 1 min [8]. Pre- and post-test measurements included oxygen saturation, heart rate and the modified Borg scale (0–10) for dyspnoea and fatigue. The test was performed twice. The highest number of repetitions was used for analyses and compared with normative values [9].

Post-operative complications <30 days after lung resection were retrospectively retrieved from the hospital records, and were classified using the Clavien–Dindo classification (grade 1–5) [10].

Age, sex, smoking status and history and body mass index (BMI) were collected. Comorbidities were assessed using the Self-Administered Comorbidity Questionnaire (SCQ). The EuroQol five-dimension

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Patients with nonsmall cell lung cancer achieving ⩽22 repetitions during a 1-min sit-to-stand test are at increased risk of post-operative complications https://bit.ly/3T7pnS9

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TABLE 1 Comparison of variables between patients with and without post-operative complications

	Total sample	No complications	Complications	p-value
Patients	44	28	16	
Country				0.33
Belgium	28 (64)	16 (57)	12 (75)	
Australia	16 (36)	12 (43)	4 (25)	
Age years	65±9	64±10	67±7	0.26
Male	27 (61)	15 (54)	12 (75)	0.21
BMI kg·m^{-2}	26.5±4.7	25.8±4.3	27.7±5.3	0.21
Height m	1.69±0.12	1.67±0.10	1.73±0.14	0.10
Smoking pack-years	36 (25–58)	31 (18–44)	55 (35–85)	**0.014**
Smoking status				0.18
Never	5 (11)	5 (18)	0	
Current	13 (30)	7 (25)	6 (38)	
Former	26 (59)	16 (57)	10 (62)	
SCQ				
Total score	7 (4–10)	7 (3–10)	7 (6–11)	0.32
Number of conditions	3 (2–4)	3 (2–4)	3.5 (4–5)	0.43
Activity limitations	1 (0–2)	0 (0–2)	1 (0–2)	0.16
Comorbidities				
Heart	7 (16)	5 (18)	2 (13)	1.00
Hypertension	20 (45)	12 (43)	8 (50)	0.76
Lung disease	12 (27)	7 (25)	5 (31)	0.73
Diabetes	4 (9)	3 (11)	1 (6)	1.00
Stomach	4 (9)	2 (7)	2 (13)	0.61
Kidney	0	0	0	
Liver	2 (5)	1 (4)	1 (6)	1.00
Blood	0	0	0	
Depression	6 (14)	3 (11)	3 (19)	0.65
Osteoarthritis	19 (43)	13 (46)	6 (38)	0.75
Back pain	15 (34)	9 (32)	6 (38)	0.75
Rheumatoid arthritis	3 (7)	2 (7)	1 (6)	1.00
Other	20 (45)	11 (39)	9 (56)	0.60
Stage				0.69
IA	21 (48)	14 (50)	7 (44)	
IB	8 (18)	5 (18)	3 (17)	
IIA	2 (5)	2 (7)	0	
IIB	5 (11)	3 (11)	2 (13)	
IIIA	5 (11)	3 (11)	2 (13)	
IIIB	3 (7)	1 (3)	2 (13)	
1MSTS reps	27 (22–29)	27.5 (25–32)	22 (21–28)	**0.021**
1MSTS % pred	77 (64–87)	78 (70–93)	73 (54–81)	0.08
S_{pO_2} (before)	97 (95–98)	97 (95–98)	97 (95–97)	0.68
Difference (after−before)	−1 (−2–0)	−1 (−2–1)	−1.5 (−3–0)	0.06
Heart rate (before)	80 (69–90)	80 (68–92)	80 (69–90)	0.69
Difference (after−before)	32 (22–40)	32 (22–44)	28 (20–40)	0.42
Borg dyspnoea (before)	0 (0–0)	0 (0–0)	0 (0–2)	0.11
Difference (after−before)	3 (1–4)	3 (1–4)	3 (2–5)	0.10
Borg fatigue (before)	0 (0–0)	0 (0–0)	0 (0–0)	0.45
Difference (after−before)	2 (1–4)	2 (1–4)	3 (1–4)	0.81
Type of lung resection				0.69
VATS	36 (82)	22 (79)	15 (94)	
Thoracotomy	8 (18)	6 (21)	1 (6)	
Extent of lung resection				0.98
Lobectomy	36 (82)	23 (82)	13 (82)	
Bi-lobectomy	3 (7)	2 (7)	1 (6)	
Wedge resection	3 (7)	2 (7)	1 (6)	
Segmentectomy	2 (4)	1 (4)	1 (6)	
Complications grade				**<0.0001**
0	28 (64)	28 (100)	0	
1	5 (11)	0	5 (31)	
2	4 (9)	0	4 (25)	

Continued

TABLE 1 Continued

	Total sample	No complications	Complications	p-value
3a	3 (7)	0	3 (19)	
3b	1 (2)	0	1 (6)	
4a	2 (5)	0	2 (13)	
4b	1 (2)	0	1 (6)	
5	0	0	0	
LOS days	6 (4–11)	5 (3–6)	11 (6–15)	**0.0002**
VAS score				
Pain	4±3	4±3	4±2	0.79
Fatigue	5 (1.5–6)	5 (1–7)	4 (2–6)	0.58
Dyspnoea	3 (1–6)	2 (1–7)	4 (0–6)	0.67
EQ-5D				
Mobility	1 (1–2)	1 (1–2)	1 (1–2)	0.70
Personal care	1 (1–2)	1 (1–1)	1 (1–2)	0.37
Usual activities	2 (1–2.5)	2 (1–3)	2 (1–2)	0.14
Pain/discomfort	2 (2–2)	2 (2–3)	2 (2–2)	0.59
Anxiety/depression	1 (1–2)	1 (1–2)	2 (1–2)	**0.036**
Total score	8±2	8±2	8±2	0.90
VAS	60 (50–70)	57±17	64±15	0.25

Data are presented as n, n (%), mean±SD or median (interquartile range). Bold type represents statistical significance. BMI: body mass index; SCQ: Self-Administered Comorbidity Questionnaire; 1MSTS: 1-min sit-to-stand test; S_{pO_2}: peripheral oxygen saturation; VATS: video-assisted thoracic surgery; LOS: length of hospital stay; VAS: visual analogue scale; EQ-5D: EuroQOL five-dimension scale questionnaire.

scale questionnaire (EQ-5D), and the visual analogue scale (VAS) for pain, fatigue and dyspnoea were assessed on day of discharge. Lung cancer stage, type of lung resection and length of hospital stay (LOS) were retrieved from the hospital records.

Analyses were performed using JMP Pro 16.2.0. Data are expressed as mean±SD, median (interquartile range) or percentages. Variables were examined for normality (Shapiro–Wilk test), and homoscedasticity (Brown–Forsythe test). To compare variables between countries and between patients with and without complications, an independent t-test or nonparametric test (Wilcoxon or Welch test) was used for continuous data. Categorical data were tested with Fisher's exact test or Chi-squared test. Receiver operating characteristic (ROC) curve analysis was performed to find a threshold for the 1MSTS to identify patients with complications [11]. The area under the curve (AUC) was interpreted as ⩽0.50 no discrimination, 0.50–0.69 poor discrimination, 0.70–0.79 acceptable discrimination, 0.80–0.89 excellent discrimination and ⩾0.90 outstanding discrimination. The accuracy of the threshold was calculated to measure the proportion of patients who had the correct prediction of the occurrence of complications. A multivariate logistic regression analysis was used to adjust the association between the 1MSTS and complications for age, sex, BMI and SCQ score.

44 patients (Belgium n=28, Australia n=16) were included and assessed a median 6 (3–14) days before lung resection. Patients were aged 65±9 years and 61% were male. They scored a median 27 repetitions on the 1MSTS (78% predicted).

Compared to the patients in Australia, patients in Belgium had a significantly lower smoking history (34±20 *versus* 62±51 pack-years; p=0.049), and were more likely to undergo VATS (100% *versus* 56%; p=0.002). After lung resection, patients in Belgium scored worse on the EQ-5D (8.5±2 *versus* 7±2; p=0.024), VAS fatigue (6 (3.5–7) *versus* 1.5 (0–5); p=0.003) and VAS dyspnoea (5 (2–6.5) *versus* 1.5 (0–0.5); p=0.017).

16 out of 44 patients had complications; mostly grade I (31%) (*i.e.* air leak) or grade II (25%) (*i.e.* pneumonia). All occurred during hospitalisation. Comparison of variables between patients with and without complications is presented in table 1.

The AUC of the ROC curve for the prediction of post-operative complications was 0.71 (95% CI 0.55–0.87) in the total sample. The optimal threshold for 1MSTS was 22 repetitions, with a sensitivity of 56% and specificity of 86%. The accuracy was 75%. Sensitivity analysis per country identified the same threshold, with an AUC of 0.72 in Belgium and 0.77 in Australia. Patients with ⩽22 repetitions (n=13) had more osteoarthritis (p=0.044) and longer LOS (p=0.007).

When adjusting for age, sex, BMI and SCQ score, the association between the 1MSTS and complications remained significant.

The findings of this multicentre study confirm the prognostic value of the 1MSTS to predict post-operative complications in patients with NSCLC. Our results suggest that a threshold of 22 repetitions acceptably predicts post-operative complications, yet this estimate comes with uncertainty ranging from poor to excellent discrimination based on the 95% confidence interval.

Patients having a pre-operative score of ⩽22 repetitions on the 1MSTS were more likely to experience complications during hospitalisation, even when accounting for age, sex, BMI and self-reported comorbidities. To our knowledge, only one previous study has examined the prognostic value of the 1MSTS on post-operative complications and found a threshold of 20 repetitions [6]. The study recorded post-operative complications graded ⩾2 on the Clavien–Dindo classification within 90 days following VATS or robotic-assisted thoracic surgery, with 75% of the complications occurring during hospital stay. In addition, they only included one center, which limited the external validity.

Compared to a CPET, the 1MSTS is less time-consuming and does not require specialised personnel or equipment. Although the 1MSTS has limitations in providing insight into specific physiological impairments, it is a more practical tool for pre-operative evaluation in clinical practice and may serve as a useful initial screening tool to identify patients who require a CPET. Moreover, risk stratification using the 1MSTS in the pre-operative period may guide patients toward prehabilitation [12].

The multicentre nature of our study increases its external validity. In addition, a threshold value for the 1MSTS was determined and adjusted for relevant cofounders, and the current study also included patients undergoing open thoracotomy. The present study has some limitations. Firstly, the coronavirus disease 2019 pandemic led to a limited sample size. Secondly, post-operative complications were retrieved from the hospital records and not specifically monitored by the research team. Thirdly, lung function data were not gathered, preventing the screening of patients based on lung function for consideration for an exercise test, and adjusting for it in the multivariate analysis. Furthermore, we did not perform a direct comparison between the 1MSTS and the CPET to investigate whether the 1MSTS can replace the known prognostic ability of $V'_{O_2 \text{peak}}$.

Our findings confirm that the 1MSTS is an easy test to predict post-operative complications in patients with NSCLC. Patients achieving ⩽22 repetitions during a 1MSTS test are at increased risk of complications and should be referred to a CPET. This simple and easily accessible test could potentially help clinicians take appropriate measures to reduce the risk of post-operative complications.

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References

1 Postmus PE, Kerr KM, Oudkerk M, *et al.* Early and locally advanced non-small-cell lung cancer (NSCLC): ESMO Clinical Practice Guidelines for diagnosis, treatment and follow-up. *Ann Oncol* 2017; 28: Suppl. 4, iv1–iv21.
2 Roy E, Rheault J, Pigeon MA, *et al.* Lung cancer resection and postoperative outcomes in COPD: a single-center experience. *Chron Respir Dis* 2020; 17: 1479973120925430.
3 Brunelli A, Kim AW, Berger KI, *et al.* Physiologic evaluation of the patient with lung cancer being considered for resectional surgery: diagnosis and management of lung cancer, 3rd ed: American College of Chest Physicians evidence-based clinical practice guidelines. *Chest* 2013; 143: 5 Suppl, e166S–e190S.
4 ATS/ACCP statement on cardiopulmonary exercise testing. *Am J Respir Crit Care Med* 2003; 167: 211–277.
5 Gephine S, Bergeron S, Tremblay Labrecque PF, *et al.* Cardiorespiratory response during the 1-min sit-to-stand test in chronic obstructive pulmonary disease. *Med Sci Sports Exerc* 2020; 52: 1441–1448.
6 Boujibar F, Gillibert A, Bonnevie T, *et al.* The 6-minute stepper test and the sit-to-stand test predict complications after major pulmonary resection *via* minimally invasive surgery: a prospective inception cohort study. *J Physiother* 2022; 68: 130–135.
7 Quadflieg K, Higgins R, Criel M, *et al.* Prognostic value of the 1-minute sit-to-stand test on postoperative complications in people with lung cancer elected for lung surgery. *Eur Respir J* 2022; 60: Suppl. 66, 4585.
8 Bohannon RW, Crouch R. 1-minute sit-to-stand test: systematic review of procedures, performance, and clinimetric properties. *J Cardiopulm Rehabil Prev* 2019; 39: 2–8.
9 Strassmann A, Steurer-Stey C, Lana KD, *et al.* Population-based reference values for the 1-min sit-to-stand test. *Int J Public Health* 2013; 58: 949–953.
10 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: 205–213.
11 Youden WJ. Index for rating diagnostic tests. *Cancer* 1950; 3: 32–35.
12 McIsaac DI, Boland L, Hutton B, *et al.* Prehabilitation in adult patients undergoing surgery: an umbrella review of systematic reviews. *Br J Anaesth* 2022; 128: 244–257.