Acta Med. Okayama, 2023
Vol. 77, No. 2, pp. 193-197

Acta Medica Okayama
http://escholarship.lib.okayama-u.ac.jp/amo/

Short Communication

Validity of the 30-Second Chair-Stand Test to Assess Exercise Tolerance and Clinical Outcomes in Patients with Esophageal Cancer: A Retrospective Study with Reference to 6-Minute Walk Test Results

Tomohiro Ikeda[a]*, Kazuhiro Noma[b,c], Kazuki Okura[d], Sho Katayama[a], Yusuke Takahashi[d], Naoaki Maeda[b,c], Shunsuke Tanabe[b,c], Akiyuki Wakita[e,f], Masanori Hamada[a], Toshiyoshi Fujiwara[b,c], and Masuo Senda[a]

[a]Department of Rehabilitation Medicine, Okayama University, [b]Department of Gastroenterological Surgery, Okayama University, Graduate School of Medicine, Dentistry and Pharmaceutical Sciences, [c]Center for Esophageal Disease, Okayama University Hospital, Okayama 700-8558, Japan, [d]Division of Rehabilitation, Departments of [e]Esophageal Surgery, [f]Thoracic Surgery, Akita University Graduate School of Medicine, Akita 010-8543, Japan

This retrospective study aimed to investigate the validity of a 30-sec chair stand test (CS-30) as a simple test to assess exercise tolerance and clinical outcomes in 53 Japanese patients with esophageal cancer. There was a strong correlation between the results of CS-30 and the 6-min walk test (6MWT), the gold standard for assessing exercise tolerance (r = 0.759). Furthermore, fewer patients whose CS-30 score was greater than 16 (the cutoff value defined based on 6MWT) experienced pneumonia in their postoperative course. These results suggest that exercise tolerance could be assessed using CS-30, and its cutoff value may be useful in predicting postoperative pneumonia risk.

Key words: esophageal cancer, exercise tolerance, rehabilitation

Esophageal cancer is the eighth most-common cancer and the sixth most-frequent cause of cancer-related death globally [1]. Surgery is a common strategy for the treatment of esophageal cancer. Low *et al.* [2] reported that 59.0% of patients with esophageal cancer experience postoperative complications. Therefore, accurate preoperative assessment of risk factors for complications and appropriate management are valuable.

Several reports have suggested that preoperative exercise tolerance in patients with esophageal cancer is associated with postoperative clinical outcomes [3-6]. The cardiopulmonary exercise test (CPET) [3,4], the 6-min walking test (6MWT) [5], and the incremental shuttle walk test (ISWT) [6] are commonly performed to assess exercise tolerance. Although all these assessments are valuable methods for predicting clinical outcomes, their implementation in general practice presents challenges because they require time, space, special equipment and/or expertise. There is a need for a new method to assess exercise tolerance that is easy to perform.

The 30-sec chair-stand test (CS-30) is a simple physical function test using a stopwatch and a chair [7]. Several studies have reported the good reliability of the chair-standing test [7-9], and its validity as an exercise tolerance test has been examined in physiological

Received May 26, 2022; accepted October 31, 2022.
*Corresponding author. Phone: +81-86-235-7752; Fax: +81-86-235-7751
E-mail: pn9375yc@s.okayama-u.ac.jp (T. Ikeda)

Conflict of Interest Disclosures: No potential conflict of interest relevant to this article was reported.

experiments on healthy volunteers and patients with chronic obstructive pulmonary disease [10-12]. Although the validity of CS-30 as an exercise tolerance test for cancer patients has been investigated in the United States [8], its validity in Asian cancer patients has remained unknown. Thus, this study aimed to investigate the validity of CS-30 as a simple test to assess preoperative exercise tolerance and clinical outcomes in Japanese patients with esophageal cancer.

Materials and Methods

The study was designed retrospectively. The study participants were patients with esophageal cancer aged 20 years or older at Okayama University Hospital and Akita University Hospital from January 2019 to March 2021. In this study, we included Japanese patients with esophageal cancer who underwent surgery after neoadjuvant therapy (high risk of cardiopulmonary dysfunction [13]). We included Japanese patients with esophageal cancer who (1) were eligible for surgery after adjuvant therapy, (2) completed neoadjuvant chemotherapy or chemoradiation, and (3) received a routine preoperative physical function assessment. Patients were included in the study if they met all three inclusion criteria. Patients were excluded if they had either (1) missing data of CS-30 or 6MWT in their electronic medical record or (2) a diagnosis of dementia. Since this study was exploratory, we did not calculate the sample size and simply included a feasible number of patients.

We performed the CS-30 preoperatively following the method presented by Jones *et al.* [7]. Physical therapists conducted the test and took care to prevent falls. A chair with a height of approximately 43 cm was used. The patient's posture at the beginning of the test was as follows: sitting in a chair with both legs shoulder-width apart, back off the backrest, and arms crossed in front of the chest. After the practice session, only one trial was performed. Patients were instructed to stand up and sit down as many times as possible in 30 seconds without hands. The numbers of times they stood up were recorded as their CS-30 score. If a patient was standing at the 30-sec mark, one was added to the total number of repetitions.

We evaluated 6MWT preoperatively following the guidelines of the American College of Chest Physicians [14]. We used a flat, straight 30 meter-walking path, and examiners explained to patients that they had to walk as long as possible for 6 min and were allowed a break during the test which the stopwatch was not paused. Examiners did not walk with patients, but patients did receive a specific message about the procedure every minute from them.

We investigated the length of stay in the intensive care unit, postoperative days until walking, complications, and 30- and 90-day overall postoperative survival of the patients. Postoperative complications were defined as grade 2 or higher according to the Clavien–Dindo classification (Japan Clinical Oncology Group postoperative complication criteria).

All statistical analyses were performed with R (version 4.0.5). The significance level in all analyses was set at $p < 0.05$. First, we gathered information about the clinicopathological characteristics, CS-30, and 6MWT. Second, we analyzed the correlation between CS-30 and 6MWT using Pearson's or Spearman's correlation coefficient after checking the normality of the data. Third, we categorized the patients who underwent the operation into two groups on the basis of the cutoff value of CS-30, as determined by the corresponding cut-off of 6MWT, and compared their clinical outcomes using the Wilcoxon rank-sum test, *t*-test, chi-square test of independence, and Fisher's exact test. The cutoff value of 6MWT for grade 2 or higher postoperative complications after esophageal cancer surgery in the Asian population was 454 m [5]. Therefore, we substituted this value (454 m) into the regression equation showing the relationship between CS-30 and 6MWT obtained in this study. We set the cutoff value of CS-30 and determined the relationship of CS-30 to the occurrence of grade 2 or higher complications after esophageal cancer surgery.

This study was approved by the Ethics Committee of Okayama University Hospital (approval number 2107-012) and the Ethics Committee of Akita University Hospital (approval number 2721), and it was conducted following the ethical standards of the responsible committee on human experimentation (institutional and national) and of the Declaration of Helsinki of 1964 and its later versions. Due to the retrospective nature of the study, the need for informed consent was waived.

Results

We enrolled 53 Japanese patients with esophageal

cancer who met the criteria. The mean age of patients was 67.1 years; 46 patients (87%) were male; mean height was 165.0 cm; mean BMI was 20.6 kg/m^2; and 36 patients (68%) had stage III-IVa esophageal cancer. Thirty-one (58%) and 22 (42%) patients received chemotherapy and chemoradiation therapy, respectively. The mean score of CS-30 was 16.9 times, and the mean distance of 6MWT was 463.2 m (Table 1). There was strong correlation between CS-30 and 6MWT (r = 0.759, 95% confidence interval = 0.615 – 0.854, $p = 0.001$).

A total of 51 (96%) patients underwent esophagectomy, and 2 patients were diagnosed as unresectable by open chest examination. Five patients (10%) who underwent resection developed pneumonia postoperatively. The regression equation showing the relationship between 6MWT and CS-30 obtained in this study was as follows: 6MWT[m] = CS-30[times]*12.88 + 245.98 (Fig. 1). Therefore, the cutoff value of CS-30 was 16, and patients were categorized on the basis of CS-30 score as follows: > 16 times (n = 22) and ≤ 16 times (n = 29). Although there was no significant difference between groups in clinical outcomes, patients whose CS-30 score was greater than 16 had a decreased risk of pneumonia (5% vs. 14%, $p = 0.375$) and started walking earlier postoperatively (day 2 vs. day 3, $p = 0.075$) (Table 2).

Discussion

The results of this study demonstrate a strong correlation between CS-30 and 6MWT, which is the gold standard for exercise tolerance assessment in Japanese patients with esophageal cancer. The findings of this study support the results of previous studies in the United States [8]. We consider that CS-30 is also valid for assessing exercise tolerance in Japanese patients with esophageal cancer, as shown in physiological experiments on healthy volunteers and patients with chronic obstructive pulmonary disease [10-12].

Furthermore, this study suggested that CS-30 may be useful in predicting the risk of postoperative pneumonia. Tang *et al.* [15] reported that CS-30 was one of the most important predictors of complications after esophagectomy for cancer. However, they did not investigate the association of individual complications (*e.g.*, pneumonia) with CS-30. The present study investigated the association between CS-30 results and individual clinical outcomes. We found that patients whose

Table 1 Clinicopathological characteristics and surgical information[a]

	Overall (n = 53)
Age (year)	67.1 (7.8)
Sex (male)	46 (87%)
Height (cm)	165.0 (6.3)
Weight (kg)	56.2 (10.5)
BMI (kg/m^2)	20.6 (3.4)
Tumor type	
SCC[b]	48 (91%)
AC[c]	4 (8%)
Other	1 (1%)
Tumor location	
Ce[d]	3 (6%)
Te[e]	48 (85%)
Ae[f]	5 (9%)
T factor[g]	
T1–T2	6 (11%)
T3–T4a	47 (89%)
N factor[g]	
N0–N1	28 (53%)
N2–N3	25 (47%)
M factor[g]	
M0	55 (100%)
Stage[g]	
I–II	17 (32%)
III–IVa	36 (68%)
CCI[h]	
0	46 (87%)
1—4	7 (13%)
Brinkman Index[i]	600 (200, 940)
GNRI[j]	94.9 (10.7)
Malnutrition[k]	31 (58.5%)
Albumin (g/dl)	3.6 (3.4, 3.9)
Neoadjuvant therapy	
Chemotherapy	31 (58%)
Chemoradiation therapy	22 (42%)
6MWT[l] (m)	463.2 (101)
CS-30[m] (times)	16.9 (6.0)
Surgical information	
Open thoracic approach	4 (8%)
Open abdominal approach	27 (53%)
Operative time (min)	569 (509.0, 646.5)
Bleeding volume (ml)	234 (110.0, 355.5)

[a]Statistics presented: median (IQR); mean (SD); n (%)
[b]SCC, squamous cell carcinoma; [c]AC, adenocarcinoma; [d]Ce, cervical esophagus; [e]Te, thoracic esophagus; [f]Ae, abdominal esophagus; [g]T factor, N factor, M factor, Stage, UICC The Union for International Cancer Control's classification 8th; [h]CCI, Charlson Comorbidity Index; [i]Brinkman Index, the number of cigarettes consumed per day multiplied by years of smoking; [j]GNRI (geriatric nutritional risk index), 1.489 × albumin (g/dl) + 41.7 × usual weight/ideal weight; [k]Malnutrition, GNRI score < 98; [l]6MWT, 6-min walking test; [m]CS-30, 30-sec chair-stand test.

CS-30 score was greater than 16 might have had a decreased risk of pneumonia, which was a new finding. Previous studies [3-6, 16] have reported that CPET, 6MWT, ISWT, and the cross-sectional measurement of the psoas muscle at the third lumbar vertebra, calculated by computed tomography, can predict postoperative complications. The results of this study suggested that CS-30 may be a new predictive marker for postoperative pneumonia.

The CS-30 is a useful evaluation test because it is easy to perform with a stopwatch and a chair. Thus, it might overcome the limitations of traditional exercise tolerance assessment methods, which require time, space, special equipment, and/or expertise. Patients with esophageal cancer are often immunocompromised after receiving neoadjuvant chemotherapy before surgery [18]. The CS-30 can be performed in a private room (*e.g.*, examination room or hospital room), thus avoiding crowded areas such as rehabilitation rooms. A feasible preoperative exercise tolerance test using CS-30 might contribute to the development of a perioperative management plan. Moreover, Do *et al.* [17] reported that multimodal inpatient rehabilitation significantly improved CS-30 compared to conventional pulmonary rehabilitation in postoperative patients with esophageal cancer. Thus, CS-30 may be a modifiable risk factor in patients with esophageal cancer.

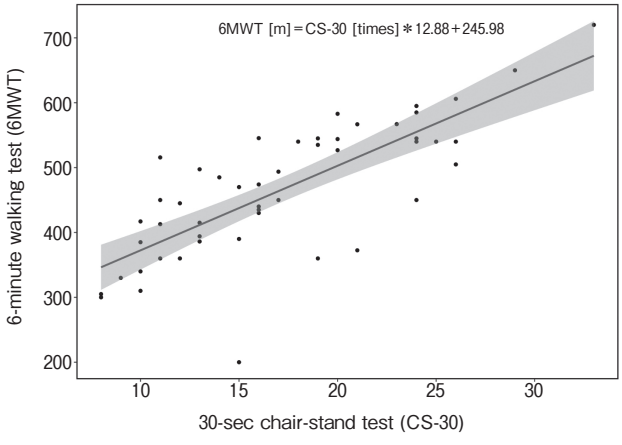

Fig. 1 Correlation between 30-sec chair-stand test (CS-30) and 6-min walking test (6MWT). There was a strong correlation between CS-30 and 6MWT ($r = 0.759$, 95% confidence interval = 0.615–0.854, $p = 0.001$). The regression equation showing the relationship between 6MWT and CS-30 obtained in this study was as follows: 6MWT[m], CS-30[times]*12.88 + 245.98.

This study had some limitations. First, it is a retrospective study; thus, we performed a comparison of CS-30 and 6MWT, which was feasible. We believe that future prospective studies should be aimed at examining the correlation between the CS-30 and CPET, which is the test that analyzes expiratory gases during exercise loading [4], to more accurately demonstrate the validity of the CS-30 as a test of exercise tolerance. Second, we included only patients from a Japanese population. Because the CS-30 is affected by height [19], the results of this study need to be carefully generalized in other populations, such as Europeans and Americans. Finally, a small number of patients participated in this study (n = 53). Although the sample size for the correlation analysis between CS-30 and 6MWT was sufficient according to G Power 3.1 (Düsseldorf, Germany) [20], it was not sufficient to analyze the rela-

Table 2 Relationship between CS-30 and clinical outcomes in patients who underwent esophagectomy[a]

	Overall	Classification by CS-30[c]		*p*-value[b]
		>16 times	≤16 times	
	(n = 51)	(n = 22)	(n = 29)	
Length of ICU[d] stay (days)	5.0 (4.0, 5.0)	5.0 (4.0, 5.0)	5.0 (5.0, 5.0)	0.163
Days to walk	3.0 (2.0, 4.0)	2.0 (2.0, 3.0)	3.0 (2.0, 4.0)	0.075
Pneumonia[e]	5 (10%)	1 (5%)	4 (14%)	0.375
Surgical site infection[e]	3 (6%)	1 (5%)	2 (7%)	1.000
30-day survival	51 (100%)	22 (100%)	29 (100%)	1.000
90-day survival	51 (100%)	22 (100%)	29 (100%)	1.000

[a]Statistics presented: median (IQR); n (%)
[b]Statistical tests performed: Wilcoxon rank-sum test; *t*-test; chi-squared test of independence; Fisher's exact test
[c]CS-30, 30-sec chair-stand test; ICU, intensive care unit; [e]Pneumonia, Surgical site infection, grade 2 or higher in the Clavien–Dindo classification.

tionship between some postoperative outcomes and CS-30. Given that the association between CS-30 scores and clinical outcomes may be influenced by confounding factors, further studies are needed to determine the relation of preoperative CS-30 to clinical outcomes in a larger sample size. This is another task for the future.

In conclusion, the results of this study suggested that CS-30 could be used to assess exercise tolerance in Japanese esophageal cancer patients and that a cutoff value of 16 may be useful in predicting the risk of postoperative pneumonia. Further studies are needed to determine the relation of preoperative CS-30 to postoperative clinical outcomes.

Acknowledgments. The authors thank Mrs. Sakamoto (Center for Innovative Clinical Medicine, Okayama University) for her assistance with the statistical analyses.

References

1. Jemal A, Bray F, Center MM, Ferlay J, Ward E and Forman D: Global cancer statistics. CA Cancer J Clin (2011) 61: 69–90.
2. Low DE, Kuppusamy MK, Alderson D, Cecconello I, Chang AC, Darling G, Davies A, D'Journo XB, Gisbertz SS, Griffin SM and Hardwick R: Benchmarking complications associated with esophagectomy. Ann Surg (2019) 269: 291–298.
3. Ashok A, Niyogi D, Ranganathan P, Tandon S, Bhaskar M, Karimundackal G, Jiwnani S, Shetmahajan M and Pramesh CS: The enhanced recovery after surgery (ERAS) protocol to promote recovery following esophageal cancer resection. Surg Today (2020) 50: 323–334.
4. Patel N, Powell AG, Wheat JR, Brown C, Appadurai IR, Davies RG, Bailey DM and Lewis WG: Cardiopulmonary fitness predicts postoperative major morbidity after esophagectomy for patients with cancer. Physiol Rep (2019) 7: e14174.
5. Inoue T, Ito S, Kanda M, Niwa Y, Nagaya M, Nishida Y, Hasegawa Y, Koike M and Kodera Y: Preoperative six-minute walk distance as a predictor of postoperative complication in patients with esophageal cancer. Dis Esophagus (2020) 33: doz050.
6. Whibley J, Peters CJ, Halliday LJ, Chaudry AM and Allum WH: Poor performance in incremental shuttle walk and cardiopulmonary exercise testing predicts poor overall survival for patients undergoing esophago-gastric resection. Eur J Surg Oncol (2018) 44: 594–599.
7. Jones CJ, Rikli RE and Beam WC: A 30-s chair-stand test as a measure of lower body strength in community-residing older adults. Res Q Exerc Sport (1999) 70: 113–119.
8. Eden MM, Tompkins J and Verheijde JL: Reliability and a correlational analysis of the 6MWT, ten-meter walk test, thirty second sit to stand, and the linear analog scale of function in patients with head and neck cancer. Physiother Theor Pract (2018) 34: 202–211.
9. Collado-Mateo D, Madeira P, Dominguez-Muñoz FJ, Villafaina S, Tomas-Carus P and Parraca JA: The automatic assessment of strength and mobility in older adults: A test–retest reliability study. Medicina (Kaunas) (2019) 55: E270.
10. Roldán-Jiménez C, Bennett P and Cuesta-Vargas AI: Muscular activity and fatigue in lower-limb and trunk muscles during different sit-to-stand tests. PLOS ONE (2015) 10: e0141675.
11. Gephine S, Bergeron S, Tremblay Labrecque PF, Mucci P, Saey D and Maltais F: Cardiorespiratory response during the 1-min Sit-to-Stand Test in chronic obstructive pulmonary disease. Med Sci Sports Exerc (2020) 52: 1441–1448.
12. Gephine S, Mucci P, Bielmann M, Martin M, Bouyer L, Saey D and Maltais F: Quadriceps physiological response during the 1-min sit-to-stand test in people with severe COPD and healthy controls. Sci Rep (2022) 12: 794.
13. Navidi M, Phillips AW, Griffin SM, Duffield KE, Greystoke A, Sumpter K and Sinclair RC: Cardiopulmonary fitness before and after neoadjuvant chemotherapy in patients with oesophagogastric cancer. Br J Surg (2018) 105: 900–906.
14. Agarwala P and Salzman SH: Six-minute walk test: Clinical role, technique, coding, and reimbursement. Chest (2020) 157: 603–611.
15. Tang A, Ahmad U, Raja S, Rappaport J, Raymond DP, Sudarshan M, Bribriesco AC, Blackstone EH and Murthy SC: Looking beyond the eyeball test: A novel vitality index to predict recovery after esophagectomy. J Thorac Cardiovasc Surg (2021) 161: 822–832.e6.
16. Ishida T, Makino T, Yamasaki M, Tanaka K, Miyazaki Y, Takahashi T, Kurokawa Y, Motoori M, Kimura Y, Nakajima K, Mori M and Doki Y: Impact of measurement of skeletal muscle mass on clinical outcomes in patients with esophageal cancer undergoing esophagectomy after neoadjuvant chemotherapy. Surgery (2019) 166: 1041–1047.
17. Do JH, Gelvosa MN, Choi KY, Kim H, Kim JY, Stout NL, Cho YK, Kim HR, Kim YH, Kim SA and Jeon JY: Effects of Multimodal Inpatient Rehabilitation vs Conventional Pulmonary Rehabilitation on Physical Recovery After Esophageal Cancer Surgery: Arch Phys Med Rehabil (2022) S0003-9993(22)00474-9.
18. Sohda M and Kuwano H: Current status and future prospects for esophageal cancer treatment. Ann Thorac Cardiovasc Surg (2017) 23: 1–11.
19. Alcazar J, Alegre LM, Van Roie E, Magalhães JP, Nielsen BR, González-Gross M, Júdice PB, Casajús JA, Delecluse C, Sardinha LB and Suetta C: Relative sit-to-stand power: Aging trajectories, functionally relevant cut-off points, and normative data in a large European cohort. J Cachexia Sarcopenia Muscle (2021) 12: 921–932.
20. Faul F, Erdfelder E, Lang AG and Buchner A: G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav Res Methods (2007) 39: 175–191.