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Association between preoperative modifiable lifestyle factors and mortality after cancer surgery: a population-based cohort study in South Korea

Tak Kyu Oh[1,2], **In-Ae Song**[1,2]

[1]*Department of Anesthesiology and Pain Medicine, Seoul National University Bundang Hospital, Seongnam, Korea*
[2]*Department of Anesthesiology and Pain Medicine, Seoul National University College of Medicine, Seoul, Korea*

Purpose: We aimed to examine whether preoperative lifestyle factors are associated with mortality after cancer surgery.
Methods: This study used data from the National Health Insurance Service database in South Korea. We included all adult patients who underwent major cancer surgery between January 1, 2016, and December 31, 2018. Three lifestyle factors were evaluated preoperatively: smoking status, alcohol consumption, and physical activity.
Results: A total of 48,557 patients who underwent major cancer surgery were included in the final analysis. In the multivariable logistic regression modeling, current smokers showed 1.40-fold higher odds of 90-day mortality after cancer surgery (odds ratio, 1.40; 95% confidence interval, 1.14–1.71; P = 0.001) than never smokers. However, alcohol consumption and physical activity were not associated with 90-day mortality after cancer surgery. In the multivariable Cox regression modeling, current smokers showed 1.25-fold higher odds of 1-year mortality after cancer surgery (hazard ratio, 1.25; 95% confidence interval, 1.13–1.38; P < 0.001) than never smokers. However, alcohol consumption and physical activity were not associated with 1-year mortality after cancer surgery.
Conclusion: In conclusion, current smoking was associated with worse short- and long-term survival outcomes in South Korea, though preoperative alcohol consumption and physical activity levels were not associated with mortality after cancer surgery.
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Key Words: Cohort studies, General surgery, Mortality, Neoplasms

INTRODUCTION

Cancer is the leading cause of death worldwide, and the global cancer burden is continuously increasing worldwide [1-3]. The most common treatment for cancer has long been surgery with a curative intent [4]. In 2015, there were 15.2 million new cases of cancer worldwide, over 80% of which required surgery [5]. Thus, the delivery of safe, affordable, and timely cancer surgery is an important health issue for global and national cancer control.

Lifestyle factors, including smoking, alcohol consumption, and physical activity, are known modifiable risk factors associated with age to first chronic disease [6]. Previous studies have reported that lifestyle factors are associated with the incidence of several diseases, including new-onset atrial fibrillation, diabetes mellitus, and kidney stone disease [7-9]. Moreover, lifestyle is a modifiable risk factor for increased all-cause mortality in the adult population [10]. Remarkably, half of all cancer risks could be influenced by lifestyle factors, including alcohol consumption, smoking, and physical activity

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Corresponding Author: In-Ae Song
Department of Anesthesiology and Pain Medicine, Seoul National University Bundang Hospital, Gumi-ro 173beon-gil, Bundang-gu, Seongnam 13620, Korea
Tel: +82-31-787-7499, **Fax:** +82-31-787-4063
E-mail: songoficu@outlook.kr
ORCID: https://orcid.org/0000-0002-7814-4253

[11]. Although lifestyle is an important and modifiable risk factor for health-related outcomes, no study has focused on the impact of preoperative lifestyle habits on mortality in patients who underwent cancer surgery.

Therefore, this study aimed to examine whether preoperative lifestyle factors are associated with mortality after cancer surgery.

METHODS

Study design and ethical statements

This study involved human participants, and all procedures were conducted in accordance with the guidelines provided by the Institutional Review Board (IRB) of the Seoul National University Bundang Hospital (No. X-2105-686-904). The National Health Insurance Service (NHIS) provided data after approval of the study protocol (NHIS-2022-1-336). The requirement for informed consent was waived by the IRB because data analyses were performed retrospectively using anonymous data derived from the South Korean NHIS database.

Data source

The NHIS database was used for data extraction. As a single public health insurance database in South Korea, NHIS contains and manages data on disease diagnoses and prescriptions for procedures and drugs. Disease diagnoses were registered using the International Classification of Diseases, External 10th Revision (ICD-10 codes). Additionally, the NHIS database contains demographic and socioeconomic status-related information for all patients in South Korea.

Study population

We initially included all adult patients (aged ≥18 years) who were admitted to the hospital and underwent major cancer surgery with curative intent from January 1, 2016, to December 31, 2018. Major cancers included lung, gastric, colorectal, esophageal, small bowel, liver, pancreatic, bile duct, and gallbladder cancers. In South Korea, patients with cancer should be registered in the NHIS database to receive financial coverage for treatment expenses. Particularly, the government supports most (approximately 95%) of the costs of treatment for patients with cancer. Among the patients who underwent major cancer surgery, we included those who had undergone standardized health examinations in the year prior to cancer surgery. In South Korea, NHIS subscribers aged ≥40 years are recommended to undergo standardized health examinations every 2 years [12].

Lifestyle factors in cancer surgery

Three lifestyle factors were evaluated before intensive care unit admission: smoking status, alcohol consumption, and physical activity. Information regarding lifestyle factors was obtained through voluntary responses to questionnaires on standardized health examinations. Smoking status was classified into 3 groups: (1) never smokers, (2) previous smokers, and (3) current smokers. In addition, the smoking pack-years of current and previous smokers were calculated to reflect the cumulative smoking amounts of both current and previous smokers. Based on a previous study [13], 0.1–20.0, 20.1–40.0, and >40.0 pack-years were used to classify current and previous smokers as light, moderate, and heavy smokers. Based on previous reports [14,15], alcohol consumption was divided into 3 groups: nondrinkers, mild drinkers, and heavy drinkers. The mild drinker group was defined as people with an alcohol consumption of ≤210 g/week in male and ≤140 g/week in female, whereas the heavy drinker group was defined as alcohol consumption of >210 g/week in male and >140 g/week in female. Physical activity was divided into 3 types according to its intensity: intensive, moderate, and mild. Intensive physical activity was defined as strenuous exercise for >20 minutes, and moderate physical activity was defined as moderate exercise without breathlessness for >30 minutes. Mild physical activity was defined as walking for >30 minutes. Each exercise frequency was divided into 4 groups: no exercise, 1 or 2 times per week, 3 or 4 times per week, 5 or 6 times per week, and 7 times per week.

Study endpoint

This study had 2 primary endpoints: 90-day mortality and 1-year postoperative all-cause mortality. Mortality was defined as death within 90 days or one year after the date of major cancer surgery.

Covariates

The covariates were collected according to the criteria of our previous study [16]. Demographic information such as age, sex, and body mass index was collected. Socioeconomic status-related information, employment status, residence, and household income levels were collected. The NHIS contains the patients' household income levels to determine the insurance premiums for the year, and approximately 67% of medical expenses are subsidized by the government [17]. However, individuals from low-income households are enrolled in the medical aid program, in which the government covers nearly all medical expenses to minimize the financial burden of medical costs. Patients were divided into 5 groups based on quartile ratios: Q1–Q4 and medical aid program groups. Residences were classified as urban (Seoul and other metropolitan cities) or rural (all other areas). Surgical cases of video-assisted laparoscopic surgery and laparoscopy were collected as covariates. The Charlson comorbidity index was calculated using the ICD-10 codes to determine the comorbidity

status of patients (Supplementary Table 1). All individuals with disabilities must be registered in the NHIS database to receive benefits from South Korea's social welfare system. In the database, patients were divided into 6 groups according to the severity of disability. We divided patients into 2 severity groups; patients with grades 1–3 disabilities were assigned to the severe disability group, whereas those with grades 4–6 were assigned to the mild-to-moderate disability group.

Statistical analysis

The clinicopathological characteristics of patients are presented as numbers with percentages for categorical variables and mean values with standard deviation (SD) for continuous variables. We constructed a multivariable logistic regression model for 90-day mortality after cancer surgery, and all covariates were included in the model for adjustment. The Hosmer-Lemeshow test was used to check whether the model of fit in the model was appropriate, and the results were presented as odds ratios (OR) with 95% confidence intervals (CI). Moreover, we constructed a multivariable Cox regression model for 1-year all-cause mortality after cancer surgery as a time-to-event analysis. All covariates were included in the model for adjustment, and the results are presented as hazard ratios (HR) with 95% CIs. Log-log plots were used to confirm that the central assumption of the Cox proportional hazards model was satisfied. The smoking pack-years of smokers were included in another multivariable model to avoid multicollinearity with smoking status. Additionally, we performed subgroup analyses according to the type of cancer surgery because smoking and alcohol are risk factors for different types of cancer [18]. The issue regarding multicollinearity between variables in the multivariable model was not observed with a criterion of variance inflation factors <2.0. All statistical analyses were performed using R software (ver. 4.0.3, R Foundation for Statistical Computing), and P-values of <0.05 were considered statistically significant.

RESULTS

Study population

From January 1, 2016, to December 31, 2018, there were 150,604 cases of major cancer surgeries in South Korea. After excluding 102,047 patients who did not have data regarding standardized health examinations in the year prior to cancer surgery, 48,557 patients who underwent major cancer surgery were included in the final analysis. Among them, 333 (0.7%), 923 (1.9%), and 3,617 (7.4%) died within 30 days, 90 days, and 1 year after cancer surgery, respectively, as shown in Fig.1. Table 1 shows the clinicopathological characteristics of patients. The mean age was 64.0 years (SD, 10.9 years), and 31,348 patients (64.6%) were male. The mean length of hospital stay was 13.0 (SD, 8.4) days, and the mean total cost of hospitalization was 8,014.4 US dollars (SD, 4,458.8 US dollars). The results of the standardized health examinations are presented in Table 2.

Survival analyses for 90-day mortality

Table 3 shows the results of the multivariable model for 90-day mortality after cancer surgery. Compared to never smokers, current smokers showed 1.40-fold higher odds of 90-day mortality after cancer surgery (OR, 1.40; 95% CI–1.14, 1.71; P = 0.001). Compared to never smokers, the 20.1–40 pack-year (moderate smokers) and >40 pack-year (heavy smokers) groups of current smokers showed 1.28-fold (OR, 1.28; 95% CI, 1.02–1.61; P = 0.035) and 1.29-fold (OR, 1.29; 95% CI–1.26, 1.32; P < 0.001) higher odds of 90-day mortality after cancer surgery, respectively. Furthermore, compared to never smokers, the >40 pack-year (heavy smokers) group of previous smokers showed 1.28-fold (OR, 1.17; 95% CI–1.03, 1.32; P = 0.040) higher odds

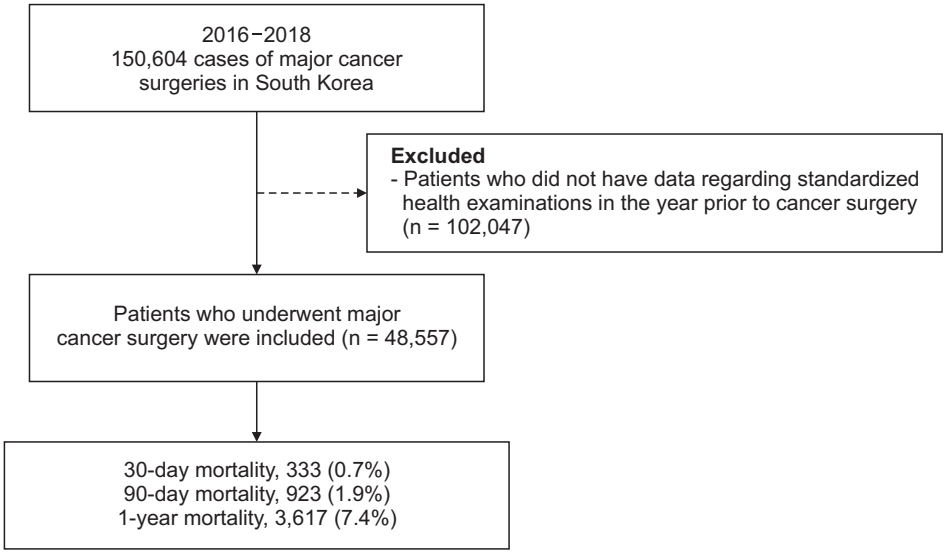

Fig. 1. Flow chart depicting the patient selection process.

Table 1. Clinicopathological characteristics of patients

Variable	Data
No. of patients	48,557
Age (yr)	64.0 ± 10.9
Male sex	31,348 (64.6)
Body mass index (kg/m^2)	
≤18.5	1,403 (2.9)
>18.5, ≤25.0	29,640 (61.0)
>25.0, ≤30.0	15,613 (32.2)
>30.0, ≤35.0	1,753 (3.6)
≥35.0	148 (0.3)
Having a job at surgery	35,503 (73.1)
Residence at surgery	
Urban area	20,740 (42.7)
Rural area	27,565 (56.8)
Unknown	252 (0.5)
Household income level	
Medical aid program	881 (1.8)
Q1	9,245 (19.0)
Q2	9,311 (19.2)
Q3	11,479 (23.6)
Q4	16,592 (34.2)
Unknown	1,019 (2.1)
Type of cancer surgery	
Lung	10,634 (21.9)
Gastric	15,122 (31.1)
Colorectal	8,081 (16.6)
Esophageal	797 (1.6)
Small bowel	1,040 (2.1)
Liver	5,683 (11.7)
Pancreatic	3,357 (6.9)
BD or GB	3,843 (7.9)
Length of hospital stay (day)	13.0 ± 8.4
Total cost for hospitalization (USD)	8,014.4 ± 4,458.8
VATS or laparoscopy	30,518 (62.8)
Charlson comorbidity index	4.8 ± 2.6
Disability at surgery	
Mild to moderate	3,979 (8.2)
Severe	1,122 (2.3)
Year of surgery	
2016	15,924 (32.8)
2017	16,181 (33.3)
2018	16,452 (33.9)

Values are presented as number (%) or mean ± standard deviation.
BD, bile duct; GB, gall bladder; USD, US dollar; VATS, video-assisted thoracoscopic surgery.
Patients were divided into 5 groups based on quartile ratios: Q1–Q4 and medical aid program groups.

of 90-day mortality after cancer surgery. Additionally, alcohol consumption and physical activity were not associated with 90-day mortality after cancer surgery. The ORs with 95% CIs of other covariates for 90-day mortality are presented in Supplementary Table 2.

Table 2. Results of the standardized health examinations

Variable	Data
Smoking status	
Never smoker	24,408 (50.3)
Previous smoker	12,728 (26.2)
Current smoker	11,421 (23.5)
Smoking of current smoker (pack-year)	
Light smoker (1–20)	5,968 (12.3)
Moderate smoker (>20, ≤40.0)	4,234 (8.7)
Heavy smoker (>40)	1,219 (2.5)
Smoking of previous smoker (pack-year)	
Light smoker (1–20)	8,070 (16.6)
Moderate smoker (>20, ≤40.0)	3,445 (7.1)
Heavy smoker (>40)	1,213 (2.5)
Alcohol consumption[a]	
No alcohol	27,093 (55.8)
Mild alcohol drinker	7,194 (14.8)
Heavy alcohol drinker	14,270 (29.4)
High-intensity PA (time/wk)[b]	
None	29,766 (61.3)
1 or 2	9,736 (20.1)
3 or 4	5,318 (11.0)
5 or 6	2,378 (4.9)
7	1,359 (2.8)
Moderate-intensity PA (time/wk)[b]	
None	26,691 (55.0)
1 or 2	10,105 (20.8)
3 or 4	6,626 (13.6)
5 or 6	3,230 (6.7)
7	1,905 (3.9)
Mild-intensity PA (time/wk)[b]	
None	13,259 (27.3)
1 or 2	8,826 (18.2)
3 or 4	10,163 (20.9)
5 or 6	8,242 (17.0)
7	8,067 (16.6)

Values are presented as number (%).
PA, physical activity.
[a]Mild, ≤210 g/wk in male and ≤140 g/wk in female; Heavy, >210 g/wk in male and >140 g/wk in female.
[b]High, strenuous exercise for >20 minutes; Moderate, moderate exercise without breathlessness for >30 minutes; Mild, walking for >30 minutes.

Survival analyses for 1-year mortality

Table 4 shows the results of the multivariable Cox model for 1-year mortality after cancer surgery. Compared with never smokers, current smokers showed 1.25-fold higher odds of 1-year mortality after cancer surgery (HR, 1.25; 95% CI, 1.13–1.38; P < 0.001). Compared to never smokers, 20.1–40 pack-year (moderate smokers) and >40 pack-year (heavy smokers) groups of current smokers showed 1.11-fold (OR, 1.11; 95% CI, 1.06–1.15; P = 0.003) and 1.21-fold (OR, 1.21; 95% CI–1.08, 1.35; P = 0.001) higher odds of 1-year mortality after cancer surgery, respectively. Additionally, alcohol consumption and physical

Table 3. Multivariable regression model for 90-day mortality after cancer surgery

Variable	OR (95% CI)	P-value
Smoking status		
Never smoker	Reference	
Previous smoker	1.08 (0.90–1.31)	0.407
Current smoker	1.40 (1.14–1.71)	0.001
Smoking of current smoker (pack-year)[a]		
Never smoker	Reference	
Light smoker (1–20)	1.00 (0.68–1.45)	0.980
Moderate smoker (>20, ≤40.0)	1.28 (1.02–1.61)	0.035
Heavy smoker (>40)	1.29 (1.26–1.32)	<0.001
Smoking of previous smoker (pack-year)[a]		
Never smoker	Reference	
Light smoker (1–20)	0.82 (0.56–1.21)	0.321
Moderate smoker (>20, ≤40.0)	1.05 (0.80–1.36)	0.742
Heavy smoker (>40)	1.17 (1.03–1.32)	0.040
Alcohol consumption[b]		
No alcohol	Reference	
Mild alcohol drinker	1.03 (0.80–1.31)	0.837
Heavy alcohol drinker	1.08 (0.89–1.30)	0.407
High-intensity PA (time/wk)[c]		
None	Reference	
1 or 2	1.02 (0.80–1.31)	0.857
3 or 4	1.07 (0.79–1.44)	0.665
5 or 6	0.96 (0.64–1.45)	0.857
7	1.17 (0.76–1.82)	0.474
Moderate-intensity PA (time/wk)[c]		
None	Reference	
1 or 2	0.94 (0.73–1.22)	0.639
3 or 4	0.99 (0.76–1.32)	0.994
5 or 6	1.08 (0.75–1.54)	0.690
7	1.01 (0.67–1.50)	0.982
Mild-intensity PA (time/wk)[c]		
None	Reference	
1 or 2	1.02 (0.81–1.28)	0.893
3 or 4	0.83 (0.67–1.04)	0.105
5 or 6	0.83 (0.66–1.05)	0.119
7	0.98 (0.80–1.21)	0.867

Hosmer-Lemeshow: χ^2 = 13.32, degree of freedom = 8 (P = 0.101).
OR, odds ratio; CI, confidence interval; PA, physical activity.
[a]Included in another multivariable model to avoid multicollinearity.
[b]Mild, ≤210 g/wk in male and ≤140 g/wk in female; Heavy, >210 g/wk in male and >140 g/wk in female.
[c]High, strenuous exercise for >20 minutes; Moderate, moderate exercise without breathlessness for >30 minutes; Mild, walking for >30 minutes.

Table 4. Multivariable Cox regression model for 1-year mortality after surgery

Variable	HR (95% CI)	P-value
Smoking status		
Never smoker	Reference	
Previous smoker	1.00 (0.91–1.10)	0.936
Current smoker	1.25 (1.13–1.38)	<0.001
Smoking of current smoker (pack-year)[a]		
Never smoker	Reference	
Light smoker (1–20)	1.00 (0.88–1.14)	0.957
Moderate smoker (>20, ≤40.0)	1.11 (1.06–1.15)	0.003
Heavy smoker (>40)	1.21 (1.08–1.35)	0.001
Smoking of previous smoker (pack-year)[a]		
Never smoker	Reference	
Light smoker (1–20)	0.92 (0.76–1.12)	0.393
Moderate smoker (>20, ≤40.0)	1.00 (0.98–1.02)	0.897
Heavy smoker (>40)	1.05 (1.00–1.09)	0.058
Alcohol consumption[b]		
No alcohol	Reference	
Mild alcohol drinker	1.32 (0.89–1.95)	0.160
Heavy alcohol drinker	1.03 (0.92–1.14)	0.515
High-intensity PA (time/wk)[c]		
None	Reference	
1 or 2	0.97 (0.87–1.09)	0.640
3 or 4	1.06 (0.92–1.22)	0.437
5 or 6	0.87 (0.71–1.06)	0.175
7	1.16 (0.93–1.44)	0.203
Moderate-intensity PA (time/wk)[c]		
None	Reference	
1 or 2	1.02 (0.91–1.15)	0.732
3 or 4	0.89 (0.78–1.02)	0.098
5 or 6	0.88 (0.74–1.06)	0.174
7	0.90 (0.73–1.10)	0.306
Mild-intensity PA (time/wk)[c]		
None	Reference	
1 or 2	1.02 (0.91–1.14)	0.778
3 or 4	0.95 (0.85–1.05)	0.303
5 or 6	0.99 (0.89–1.11)	0.916
7	1.00 (0.90–1.11)	0.998

HR, hazard ratio; CI, confidence interval; PA, physical activity.
[a]Included in another multivariable model to avoid multicollinearity.
[b]Mild, ≤210 g/wk in male and ≤140 g/wk in female; Heavy, >210 g/wk in male and >140 g/wk in female.
[c]High, strenuous exercise for >20 minutes; Moderate, moderate exercise without breathlessness for >30 minutes; Mild, walking for >30 minutes.

activity were not associated with 1-year mortality after cancer surgery. The HRs with 95% CIs of other covariates for 1-year mortality are shown in Supplementary Table 3. Survival plots derived from the multivariable Cox regression model according to smoking status are shown in Fig. 2.

Subgroup analyses

Table 5 shows the results of subgroup analyses for 90-day mortality. Compared to never smokers, current smokers showed higher 90-day mortality in the lung cancer surgery group (OR, 1.72; 95% CI, 1.09–2.73; P = 0.021) and colorectal cancer surgery group (OR, 1.57; 95% CI, 1.01–2.43; P = 0.046). Compared to never smokers, previous smokers showed higher 90-day mortality in the lung cancer surgery group (OR, 1.52; 95% CI–

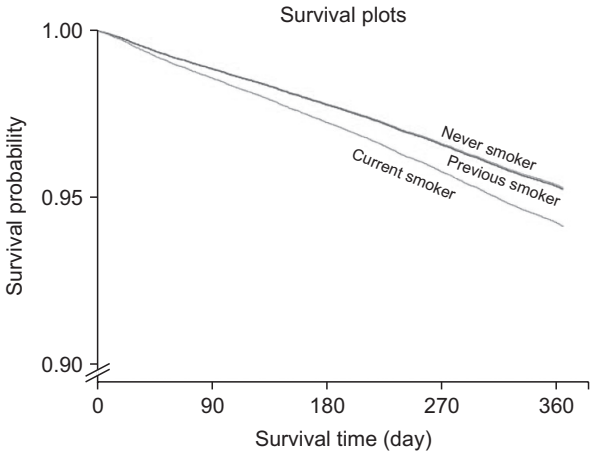

Fig. 2. Survival plots derived from the multivariable Cox regression model according to smoking status.

Table 5. Subgroup analyses for 90-day mortality

Variable	OR (95% CI)	P-value
Lung cancer surgery group		
Smoking status		
Never smoker	Reference	
Previous smoker	1.52 (1.02–2.38)	0.043
Current smoker	1.72 (1.09–2.73)	0.021
Alcohol consumption		
No alcohol	Reference	
Mild alcohol drinker	0.94 (0.57–1.57)	0.820
Heavy alcohol drinker	0.92 (0.55–1.54)	0.743
Gastric cancer surgery group		
Smoking status		
Never smoker	Reference	
Previous smoker	1.32 (0.80–2.19)	0.282
Current smoker	1.29 (0.74–2.25)	0.374
Alcohol consumption		
No alcohol	Reference	
Mild alcohol drinker	0.97 (0.52–1.80)	0.911
Heavy alcohol drinker	0.83 (0.45–1.52)	0.544
Colorectal cancer surgery group		
Smoking status		
Never smoker	Reference	
Previous smoker	0.78 (0.52–1.19)	0.252
Current smoker	1.57 (1.01–2.43)	0.046
Alcohol consumption		
No alcohol	Reference	
Mild alcohol drinker	1.09 (0.60–1.97)	0.764
Heavy alcohol drinker	1.36 (0.66–2.79)	0.409
Esophageal cancer surgery group		
Smoking status		
Never smoker	Reference	
Previous smoker	1.25 (0.39–3.97)	0.704
Current smoker	0.89 (0.27–2.96)	0.847
Alcohol consumption		
No alcohol	Reference	
Mild alcohol drinker	1.22 (0.23–6.56)	0.814
Heavy alcohol drinker	1.37 (0.14–13.26)	0.783
Small bowel cancer surgery group		
Smoking status		
Never smoker	Reference	
Previous smoker	1.15 (0.52–2.52)	0.731
Current smoker	2.05 (0.91–4.64)	0.085
Alcohol consumption		
No alcohol	Reference	
Mild alcohol drinker	1.68 (0.61–.4.62)	0.319
Heavy alcohol drinker	0.86 (0.16–4.58)	0.863
Liver cancer surgery group		
Smoking status		
Never smoker	Reference	
Previous smoker	0.90 (0.52–1.54)	0.693
Current smoker	1.37 (0.79–2.43)	0.249
Alcohol consumption		
No alcohol	Reference	
Mild alcohol drinker	0.77 (0.41–1.40)	0.382
Heavy alcohol drinker	1.21 (0.70–2.09)	0.494
Pancreatic cancer surgery group		
Smoking status		
Never smoker	Reference	
Previous smoker	1.59 (0.81–3.12)	0.181
Current smoker	1.90 (0.94–3.82)	0.072
Alcohol consumption		
No alcohol	Reference	
Mild alcohol drinker	1.18 (0.52–2.66)	0.696
Heavy alcohol drinker	1.11 (0.44–2.78)	0.827
BD or GB cancer surgery group		
Smoking status		
Never smoker	Reference	
Previous smoker	0.77 (0.43–1.36)	0.369
Current smoker	0.86 (0.44–1.68)	0.652
Alcohol consumption		
No alcohol	Reference	
Mild alcohol drinker	0.99 (0.39–2.48)	0.980
Heavy alcohol drinker	0.62 (0.12–3.14)	0.560

OR, odds ratio; CI, confidence interval; BD, bile duct; GB, gall bladder.
Alcohol consumption: Mild, ≤210 g/wk in male and ≤140 g/wk in female; Heavy, >210 g/wk in male and >140 g/wk in female.

1.02, 2.38; P = 0.043). Alcohol consumption was not associated with 90-day mortality after each cancer surgery.

DISCUSSION

This population-based cohort study showed that, among preoperative lifestyle factors, current smoking status was associated with increased 90-day and 1-year mortality rates after major cancer surgery in South Korea. These associations were more evident in the moderate and heavy smoker groups on considering cumulative smoking amounts. However,

preoperative alcohol consumption and physical activity levels were not associated with mortality after cancer surgery, suggesting that current smoking may be a risk factor for increased mortality after cancer surgery.

Previous studies reported that current smoking increased in-hospital mortality by approximately 20% and major postoperative complications by 40% [19]. A previous meta-analysis reported that current smoking during cancer treatment, including surgery, radiation, and systemic treatment, is associated with increased overall and cancer-specific mortality [20]. In addition to this literature, we reported that current smoking was associated with increased short- and long-term mortality after major cancer surgery.

Moreover, it was more evident in the moderate and heavy smoker groups on considering cumulative smoking amounts. A previous study reported that the duration and intensity of smoking should be considered together, using pack-years, in determining the risk of developing smoking-related diseases [21]. For example, it was reported that lifetime smoking exposure, measured in pack-years, was more useful than the current smoking status in evaluating mortality risk in patients with breast cancer [22]. Lifetime smoking exposure in pack-years was also used as a prognostic factor for long-term survival outcomes among patients with non-small cell lung cancer [23]. Our results also showed that the light smoker group of current smokers was not associated with 90-day mortality after cancer surgery, while the heavy smoker group of previous smokers was significantly associated on considering lifetime pack-years of smoking. Therefore, preoperative lifetime exposure to smoking might be a better indicator for predicting postoperative mortality in patients who underwent cancer surgery.

The results of alcohol consumption reported herein should be interpreted with caution. Neither mild nor heavy alcohol consumption was associated with mortality after major cancer surgery. However, the relationship between preoperative alcohol consumption and postoperative mortality has not yet been identified. A meta-analysis reported that preoperative alcohol consumption was associated with increased postoperative complications, including postoperative morbidity, infections, wound complications, pulmonary complications, prolonged hospital stay, and admission to the intensive care unit [24]. However, another prospective observational study reported that preoperative alcohol consumption is not associated with postoperative complications [25]. In patients with colorectal cancer, alcohol consumption was not associated with postoperative complications after colorectal cancer surgery [26]. While previous studies have focused on the relationship between preoperative alcohol consumption and the occurrence of postoperative complications [24-26], we showed that preoperative alcohol consumption was associated with neither short- nor long-term mortality after major cancer surgery.

The nonsignificant relationship between preoperative physical activity and mortality after cancer surgery was also important in this study. As physical activity is known to decrease all-cause and cancer-specific mortality in the general adult population [27], it is an important and modifiable factor in patients with cancer. Moreover, physically active individuals have been reported to have a faster self-assessed physical recovery after colorectal cancer surgery [28], cholecystectomy [29], and lung cancer resection [30]. However, previous studies did not focus on mortality after cancer surgery [28-30], whereas we focused on the relationship between preoperative physical activity and mortality after major cancer surgery. Therefore, further studies are needed to confirm the relationship between preoperative physical levels and surgical outcomes after cancer surgery.

This study had some limitations. First, each tumor stage among patients with major cancer was not evaluated, because the NHIS database did not have information on the tumor stage at cancer surgery, yet it could affect mortality after cancer surgery. Second, NHIS subscribers aged ≥40 years are recommended to undergo standardized health examinations every 2 years [12]; therefore, the study population included relatively older patients with a mean age of 64.0 years (SD, 10.9 years). If we critically included patients aged <40 years who underwent major cancer surgery, the results may have been different. Third, there might be some residual confounders in this study, which might have affected the results of multivariable modeling. Finally, the generalizability of the results of this study may be limited because the environment or health policies for patients with cancer differ by country.

In conclusion, we showed that, among preoperative lifestyle factors, current smoking status was associated with increased 90-day and 1-year mortality rates after major cancer surgery in South Korea, though preoperative alcohol consumption and physical activity levels were not.

SUPPLEMENTARY MATERIALS

Supplementary Tables 1–3 can be found via https://doi.org/10.4174/astr.2023.105.4.179.

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Conflict of Interest

No potential conflict of interest relevant to this article was reported.

ORCID iD

Tak Kyu Oh: https://orcid.org/0000-0002-4027-4423
In-Ae Song: https://orcid.org/0000-0002-7814-4253

Author Contribution

Conceptualization, Formal Analysis, Investigation: all authors
Methodology: TKO
Project Administration: IAS
Writing – Original Draft: TKO
Writing – Review & Editing: all authors

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