

# The effect of tobacco consumption and body mass index on complications and hospital stay after inguinal hernia surgery

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Received: 1 October 2006 / Accepted: 6 November 2006  
♥ Springer-Verlag 2006

## Abstract

**Background** The extent to which lifestyle factors such as tobacco consumption and obesity affect the outcome after inguinal hernia surgery has been poorly studied. This study was undertaken to assess the effect of smoking, smokeless tobacco consumption and obesity on postoperative complications after inguinal hernia surgery. The second aim was to evaluate the effect of tobacco consumption and obesity on the length of hospital stay.

**Methods** A cohort of 12,697 Swedish construction workers with prospectively collected exposure data on tobacco consumption and body mass index (BMI) from 1968 onward were linked to the Swedish inpatient register. Information on inguinal hernia procedures was collected from the inpatient register. Any postoperative complication occurring within 30 days was registered. In addition to this, the length of hospitalization was calculated. The risk of postoperative complications due to tobacco exposure and BMI was estimated using a multiple logistic regression model and the length of

hospital stay was estimated in a multiple linear regression model.

**Results** After adjusting for the other covariates in the multivariate analysis, current smokers had a 34% (OR 1.34, 95% CI 1.04, 1.72) increased risk of postoperative complications compared to never smokers. Use of “Swedish oral moist snuff” (snus) and pack-years of tobacco smoking were not found to be significantly associated with an increased risk of postoperative complications. BMI was found to be significantly associated with an increased risk of postoperative complications ( $P = 0.04$ ). This effect was mediated by the underweighted group (OR 2.94; 95% CI 1.15, 7.51). In a multivariable model, increased BMI was also found to be significantly associated with an increased mean length of hospital stay ( $P < 0.001$ ). There was no statistically significant association between smoking or using snus, and the mean length of hospitalization after adjusting for the other covariates in the model.

**Conclusion** Smoking increases the risk of postoperative complications even in minor surgery such as inguinal hernia procedures. Obesity increases hospitalization after inguinal hernia surgery. The Swedish version of oral moist tobacco, snus, does not seem to affect the complication rate after hernia surgery at all.

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**Keywords** Inguinal hernia · Smoking · Smokeless tobacco · Body mass index · Postoperative complications

## Introduction

Tobacco smoking is a well-known risk factor for complications after major surgical procedures. Cigarette

smokers are more prone to postoperative infections [1], and wound infections occur twice as often in smokers than in nonsmokers [2]. The need for postoperative intensive care is greater after heavy smoking [3], as is the frequency of pulmonary complications [4, 5]. Smokers have a higher incidence of inguinal hernia and an increased recurrence rate following hernia surgery [6, 7]. The effect of smoking on the postoperative complication rate after inguinal hernia surgery has not been well described, but wound healing complications would be expected [1, 8], although the results are contradictory regarding the relationship between smoking and wound infections in surgery [9, 10]. Other forms of tobacco have not been studied in relation to hernia surgery. “Swedish oral moist snuff” (snus) is widely used in Scandinavia as an alternative to smoking and has a high level of nicotine deliverance. The impact of snus on postoperative complications is not known.

Obesity has been studied as a risk factor after major surgical procedures with equivocal results [11–13]. To the best of our knowledge, the influence of obesity on the rate of complications after inguinal hernia surgery has not been investigated previously.

The aim of this study was to investigate the effect of tobacco consumption (smoking or snus) and obesity on the postoperative complication rate after inguinal hernia repair. The second aim was to determine whether or not tobacco consumption and obesity affect the length of hospital stay after inguinal hernia surgery.

## Materials and methods

### Study setting

The Swedish Construction Industry’s Organization for Working Environment Safety and Health (Bygghälsan), established in 1968, provided outpatient medical services to construction workers all over Sweden from 1969 to 1992 [14, 15]. The main activity was preventive health checkups, offered to all blue- and white-collar workers in the building industry through regular personal invitations and visits to outpatient clinics or advertisements at virtually all major building sites. Since 1971, data from these health checkups have been compiled in a computerized central register.

### Exposure assessment

Before every visit each worker filled out a self-administered questionnaire seeking exposure information. On an average, each cohort member underwent three

health check-ups. To avoid misunderstandings or inconsistencies the answers were double-checked by a nurse. The questionnaires were extensive and comprised almost 200 items, including, among other things, a detailed tobacco consumption history, anthropometric measurements, and occupational coding in 200 categories. The quality of the smoking data has been reviewed and, on comparing answers 2–3 years apart, perfect concordance was found in 89% of the cases [16]. Values were missing for 1.3% of current and 1.4% of previous smokers, and inconsistencies were found in 2.6% of the smoking data. Inconsistencies in the snus data were present for 7% of the workers.

### Inpatient register

The Swedish inpatient register was established in 1964 and has had complete national coverage from 1987 onward [17]. The Register stores patient discharge data from all publicly funded hospitals in Sweden, which is the vast majority. Each patient record corresponds to one hospital admission and contains, in addition to the national personal identification number (a unique ten-digit identifier assigned to all legal Swedish residents), the dates of admission and discharge, information about the type of admission (elective/emergency), discharge destination (home, other hospitals or departments, senior citizens home, death) and discharge diagnoses coded according to the Swedish version of the International classification of diseases (ICD). Each patient record also lists up to 12 surgical codes assigned according to the Swedish classification of operations and major procedures. The register has been evaluated for validity and completeness, and the codes for the main diagnoses were correct at the three-digit level for 92–94% of the records on surgical patients [18]. For surgical procedures (excluding endoscopies and biopsies), the codes were incorrect for 2% of the records and were missing for 5.3%. We were able to follow each patient until 31 December 2004.

### Cohort identification

Using the personal identification number for record linkage to the inpatient register, construction workers who had undergone open inguinal hernia repair were identified. We selected inguinal hernias that were repaired with open suture repair or with open mesh repair (surgical codes 4200 and 4203 before 1997 and JAB 10 and JAB 30 from 1997 onward). In all, there were 23,812 cohort members who had undergone

inguinal hernia repair. We selected only the first-time inguinal hernia procedure, and thus 4,316 observations were excluded. Further exclusions included women ( $n = 115$ ), exposure data missing ( $n = 1,785$ ), surgery before entry into the cohort ( $n=3,169$ ), patients with other main diagnosis than inguinal hernia ( $n = 1,188$ ), erroneous personal identification numbers ( $n = 570$ ), and patients who underwent another major surgical procedure at the same time ( $n = 593$ ). Finally, 621 subjects with repeated hospitalizations in conjunction with the same hernia repair were counted only once. The final cohort therefore consisted of 12,697 male subjects. The majority had an open suture repair ( $n = 11,198$ , 88.2%), and 1,499 patients had an open mesh repair.

In order to attain the most complete tobacco exposure status, we strived to use the questionnaire information from the period 1971 to 1974 or 1978 and later. This resulted in 4,176 patients with exposure information from 1978, 66 individuals with tobacco exposure status from the period 1975 to 1977, and the rest from before 1975.

## Study outcomes

### *Postoperative complications*

We went through the Swedish inpatient register using the Swedish versions of ICD-8 to ICD-10 and the Swedish classification of operation and major procedures, in order to collect information on postoperative complications that had occurred from the day of surgery and 30 days onward. All deaths within 30 days were identified using information from the Swedish death register. In addition to obvious complications such as wound infection or myocardial infarction, any adverse event that could be regarded as a complication to surgery was included. General complications such as peptic ulcer, fever of unknown origin, and small bowel obstruction were placed in the systemic group. This review resulted in the seven categories of complications presented in Table 1. Patients could be registered for more than one complication during the follow-up. In order to have more stable groups in terms of sample size, all complications, including cases of death within 30 days, were grouped into a single category (any complication).

### *Length of hospital stay*

Every individual was followed until the day of discharge home. Patients ( $n = 621$ ) who were discharged from one clinic and admitted to another one on the

**Table 1** Frequency of postoperative complications in male patients undergoing first-time inguinal hernia surgery

Postoperative complications	<i>N</i> (12,697)	%
Infectious	121	1.0
Cardiovascular	38	0.3
Thromboembolic	30	0.2
Bleeding	109	0.9
Reoperation	78	0.6
Systemic	65	0.5
Death	11	0.1
Any complication (total)	368	2.9

same day were considered to still be undergoing treatment or observation due to the hernia procedure and were followed until discharged home.

## Statistical analyses

The distribution of BMI was analyzed in four classes according to the World Health Organization (WHO) criteria: underweight <18.5, normal weight 18.5–24.9; overweight, 25–29.9, and obese >30. When assessing the total amount of tobacco smoked by a worker every day, cigarettes were assumed to contain 1 g of tobacco and cigars 6 g of tobacco. Pipe smokers reported the amount of tobacco in grams consumed every week.

Stratified categorical data analysis and a logistic regression model were performed to study the probability of developing complications within 30 days from surgery. In order to avoid multicollinearity, different tobacco-related exposure factors were analyzed separately, achieving different final models. Logistic regression was used to estimate the adjusted odds-ratio and its 95% confidence interval.

Descriptive statistics were subsequently employed to summarize the hospital stay. Natural log transformation was applied to improve symmetry and normality when performing multiple linear regressions. The multivariable *F* test was used to assess the significance of each simple variable added to the model (a *P* value <0.05 was considered significant). The overall goodness of fit of the model was studied by means of the adjusted  $r^2$ , residual analyses (based on both crude and studentized residuals) were performed to assess the validity of assumptions in the linear regression, and diagnostics analyses were performed to identify possible outlying patients. Stata 9.1 was used to perform the statistical analyses (StataCorp 2005. Stata Statistical Software Release 9. College Station, TX, StataCorp LP).

## Results

### Postoperative complications

Baseline characteristics according to postoperative complications and hospital stay are presented in Table 2. The entire cohort of 12,697 subjects had a mean age of 56.5 years and a mean BMI of 24.6. Current smokers constituted 39.3%, previous smokers 24.3%, and never smokers 36.4%. Ever snus users accounted for 20.9% and never users 79.1%. The overall complication rate was 2.9%. After adjusting for the other covariates in the multivariable logistic regression analysis, current smokers had a 34% (OR 1.34; 95% CI 1.04, 1.72) increased risk of postoperative complications compared to never smokers (Table 3). Snus use and pack-years of tobacco smoking were not found to be significantly associated with an increased risk of postoperative complications.

BMI was also found to be significantly associated with an increased risk of postoperative complications ( $P=0.04$ ). The underweight had an increased risk of complications (OR 2.94; 95% CI 1.15, 7.51). There was a trend to an increase in the risk of postoperative

complications in connection with obesity ( $P = 0.07$ ). Obese patients had a 57% (OR 1.57; 95% CI 0.96, 2.57) increased risk of postoperative complications in comparison with the normally weighted reference group.

### The length of hospital stay

The overall mean and median lengths of hospital stay were 3.1 and 2 days, respectively. In a multivariable model, an increased BMI was found to be significantly associated with an increased mean length of the hospital stay ( $P < 0.001$ ), as shown in Table 4. On the log scale, the mean length of hospital stay among the overweight and obese patients increased 0.05 and 0.13, respectively, compared to the normally weighted. Based on a useful interpretation of the log transformation [19], the mean length of the hospital stay increased 5% (95% CI 3.0, 7.0%) in the overweight group and 13.0% (95% CI 8.0, 18.0%) in the obese group. There was no statistically significant association between smoking or snus use and the mean length of hospitalization after adjusting for the other covariates in the model.

**Table 2** Baseline characteristics of patients undergoing inguinal hernia surgery according to the length of hospital stay and complication rate

	N (%)	Median Length of hospital stay (days)	Mean (SD)	25th–75th	Complication rate N (% within strata)
Age category (years) <sup>a</sup>					
17–34	1,141 (9.0)	2	2.8 (1.6)	2–4	17 (1.5)
35–44	1,644 (13.0)	2	2.7 (1.6)	2–3	40 (2.4)
45–54	2,380 (18.8)	2	2.8 (2.7)	2–4	47 (2.0)
55–64	3,385 (26.8)	2	3.0 (2.5)	2–4	98 (2.9)
65–74	2,846 (22.5)	2	3.7 (23.3)	2–4	94 (3.3)
75–95	1,249 (9.9)	2	3.6 (21.5)	2–3	72 (5.8)
Body mass index <sup>a</sup>					
<18.5	74 (0.6)	2	2.7 (2.2)	1–4	5 (6.8)
18.5–24.9	6,906 (54.9)	2	2.8 (4.4)	2–3	183 (2.7)
25–29.9	5,114 (40.1)	2	3.4 (16.7)	2–4	157 (3.1)
30–max	488 (3.9)	3	4.8 (31.2)	2–4	19 (3.9)
Planning of surgery <sup>a</sup>					
Planned	9,419 (80.0)	2	3.1 (12.3))	2–4	248 (2.6)
Acute	2,362 (20.0)	2	3.5 (17.8)	2–4	102 (4.3)
Overall smoking status					
Never	4,555 (35.9)	2	3.0 (10.6)	2–4	117 (2.6)
Previous	3,348 (26.4)	2	3.0 (2.6)	2–4	87 (2.6)
Current	4,794 (37.8)	2	3.4 (18.5)	2–4	164 (3.4)
Snus status					
Never	9,937 (78.3)	2	2.9 (2.7)	2–4	291 (2.9)
Ever	2,760 (21.7)	2	3.2 (14.7)	2–4	77 (2.8)
Pack-years of tobacco use <sup>a</sup>					
None	4,555 (37.3)	2	3.1 (11.5)	2–4	117 (2.6)
0–9.9	3,303 (27.1)	2	3.1 (14.2)	2–4	95 (2.9)
10–19.9	2,390 (19.6)	2	4.4 (29.0)	2–4	83 (3.5)
20–29.9	995 (8.2)	2	2.7 (1.8)	2–3	31 (3.1)
30–max	962 (7.9)	2	2.9 (2.6)	2–4	29 (3.0)

<sup>a</sup> Missing values make the total sum of  $n$  differ from 12,697

**Table 3** Adjusted odds ratios (ORs) and corresponding 95% confidence intervals (CIs) of the rate of postoperative complications according to tobacco exposure and BMI category obtained from logistic regression analyses

	Any complication			Overall <i>P</i> value
	OR	95% CI	<i>P</i> value	
Overall smoking status <sup>a</sup>				0.02
Never	–	–		
Previous	0.95	0.71–1.28	0.75	
Current	1.34	1.04–1.72	0.02	
Snus status <sup>a</sup>				0.62
Never	–	–		
Ever	0.93	0.71–1.22	0.62	
Pack-years of smoking <sup>a</sup>				0.43
None	–	–		
>0–9.9	1.11	0.83–1.48	0.47	
10–19.9	1.34	1.00–1.81	0.05	
20–29.9	1.12	0.74–1.73	0.58	
30–max	1.14	0.74–1.76	0.54	
Body mass index <sup>b</sup>				0.04
<18.5	2.94	1.15–7.51	0.02	
18.5–24.9	–	–	–	
25–29.9	1.16	0.92–1.46	0.20	
30–max	1.57	0.96–2.57	0.07	

<sup>a</sup> Each tobacco-related exposure variable was fitted separately. All final models were adjusted for age, calendar period, BMI, and acute surgery

<sup>b</sup> The final model for BMI was adjusted for age, calendar period, smoking status, and acute surgery

## Discussion

In our study, current smoking was found to be significantly associated with postoperative complications. We believe that this is a somewhat expected finding, but it has not previously been demonstrated for such a common minor surgical procedure as inguinal hernia repair. Also, in this material current smoking was an independent risk factor for postoperative infection ( $P = 0.02$ , data not shown), but the numbers were too small to determine if this was due to wound infections or systemic infections. Increasing age was also an independent risk factor for postoperative infection ( $P = 0.02$ , data not shown), which is in contrast to some other studies that did not find any relationship between age and postoperative wound infection [20, 21]. Use of snus did not affect either the complication rate or the hospitalization time after inguinal hernia surgery, which is interesting since snus is presently more widely used among Swedish men than smoking tobacco. According to the Swedish National Institute of Public

**Table 4** Adjusted regression coefficients and corresponding 95% confidence intervals (CIs) for changes in the mean length of hospital stay according to tobacco exposure and BMI data from multivariable linear regression analyses

	Coef	95% CI	Overall <i>P</i> value
Overall smoking status <sup>a</sup>			0.42
Never	–	–	
Previous	0.00	–0.03 to 0.02	
Current	0.01	–0.01 to 0.03	
Snus status <sup>a</sup>			0.15
Never	–	–	
Ever	0.02	0.00 to 0.04	
Pack-years of tobacco use <sup>a</sup>			0.74
None	–	–	
0.1–9.9	–0.01	–0.03 to 0.02	
10–19.9	0.01	–0.02 to 0.04	
20–29.9	0.01	–0.03 to 0.05	
30–max	0.01	–0.02 to 0.05	
Body mass index category <sup>b</sup>			<0.001
<18.5	0.05	–0.07 to 0.17	0.44
18.5–24.9	–	–	–
25–29.9	0.05	0.03 to 0.07	<0.001
30–max	0.13	0.08 to 0.18	<0.001

<sup>a</sup> Each tobacco-related exposure variable was fitted separately. All final models were adjusted for age, calendar period, BMI, and acute/elective surgery

<sup>b</sup> The final model for BMI was adjusted for age, calendar period, smoking status, and acute/elective surgery

Health in 2005, 22% of Swedish men used snus on a daily basis and 13% smoked, the corresponding figures for women being 4 and 17%.

It has previously been shown that other factors than nicotine per se cause the adverse effects of smoking. Two randomized trials of smoking cessation used nicotine substitution and still reduced the postoperative complication rate significantly [1, 8]. The underlying mechanism of complications probably has multiple causes. Smoking decreases collagen synthesis [22], increases systemic inflammation [23], causes leukocyte dysfunction [24], and decreases tissue oxygenation [25]. All these mechanisms may disturb wound healing, but the details remain unclear and warrant further investigations.

Both being obese and underweight increased the complication rate, although the finding was marginally statistically significant for obesity ( $P = 0.07$ ). The increased risk of postoperative complications among underweight patients could be due to confounding factors, especially malignant diseases. Being obese and overweight did prolong the hospitalization period up to 13%, a finding which, to our knowledge, has not been



reported before. The finding might be a surrogate for a higher complication rate and certainly increases costs for the health care system. In a recent cohort study, a high BMI was also associated with an increased risk for venous thromboembolism (VTE), whereas smoking did not elevate the risk of VTE [26]. Neither of these findings could be evaluated in this study due to the small number of VTE cases ( $n = 20$ ).

This study has the advantage of using prospectively collected information on tobacco exposure and is based on a very large sample size. It also benefits from a unique quality of data with regards to tobacco: the type of tobacco used and the dose and duration of use, as well as the use of snus have been recorded. The low overall frequency of postoperative complications within 30 days (2.9%) is largely due to the failure of complete registration in the Swedish inpatient register. The true number is likely to be closer to 9%, which is the overall complication frequency in the Swedish Hernia Registry for the period 1992–1997 [27]. Nearly half of the reoperations due to surgical complications are not reported in the Swedish inpatient register, and the frequency of missing data on minor complications such as a wound infection is even higher [28]. This should not affect the results of this study since we have no reason to believe that a low reporting frequency is related to smoking or BMI, i.e., any misclassification is most likely non-differential. There may also be a healthy worker effect that could keep the frequency of complications low in general. Furthermore, our mortality rate of 0.1% is consistent with earlier findings of postoperative mortality after inguinal hernia repair [29]. Also in our study, acute hernia surgery had a much higher frequency of complications than elective surgery, which has been shown previously [30]. Complications increase with the calendar period, which is an expected effect of increased demands on the registration of multiple diagnoses in the health economics system used in Sweden.

In conclusion, smoking increases the risk of postoperative complications even in such minor surgery as inguinal hernia repair. Obesity increases hospitalization and should be taken into account when scheduling the obese for hernia surgery. Oral moist tobacco in the Swedish version, snus, does not seem to affect the complication rate after hernia surgery at all. Thus, more efficient prevention measures should be considered in order to reduce the negative impact of smoking and obesity on surgical results.

**Acknowledgments** We wish to express our thanks to Klas Pekkar, MD, PhD, for his valuable comments and careful reading of the manuscript.

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