ORIGINAL ARTICLE

Smoking Is a Risk Factor for Incisional Hernia

Lars Tue Sørensen, MD; Ulla B. Hemmingsen, RN; Lene T. Kirkeby, MD; Finn Kallehave, MD; Lars Nannestad Jørgensen, MD, DMSci

Hypothesis: A number of risk factors for incisional hernia have been identified, but the pathogenesis remains unclear. Based on previous findings of smoking as a risk factor for wound complications and recurrence of groin hernia, we studied whether smoking is associated with incisional hernia.

Design: Cohort study. Clinical follow-up study for incisional hernia 33 to 57 months following laparotomy for gastrointestinal disease. Variables predictive for incisional hernia were assessed by multiple regression analysis.

Setting: Department of Surgery, Bispebjerg Hospital, University of Copenhagen, Copenhagen, Denmark.

Patients: All 916 patients undergoing laparotomy from 1997 through 1998. Surgeons performed clinical examination in 310 patients; patients who failed to meet for examination, died, or were lost to follow-up were excluded.

Main Outcome Measures: Thirty-four variables related to patient history, preoperative clinical condition, operative severity and findings, and the surgeon's training.

Results: The incidence of incisional hernia was 26% (81/310). Smokers had a 4-fold higher risk of incisional hernia (odds ratio [OR], 3.93 [95% confidence interval (CI), 1.82-8.49]) independent of other risk factors and confounders. Relaparotomy was the strongest factor associated with hernia (OR, 5.89 [95% CI, 1.78-19.48]). Other risk factors were postoperative wound complications (OR, 3.91 [95% CI, 1.99-7.66]), age (OR, 1.04 [95% CI, 1.02-1.06]), and male sex (OR, 2.17 [95% CI, 1.21-3.91]).

Conclusion: Smoking is a significant risk factor for incisional hernia in line with relaparotomy, postoperative wound complications, older age, and male sex.

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Author Affiliations:
Department of Surgery, Bispebjerg Hospital, University of Copenhagen, Copenhagen, Denmark.

INCISIONAL HERNIA IS A LATE COMplication following abdominal surgery, occurring as a result of breakdown or loss of fascial closure and, as such, a iatrogenic disease.[1] The incidence after laparotomy has been reported as ranging between 4% and 12% in large series,[2-6] but the true incidence is probably underestimated.[7] Many incisional hernias are asymptomatic, but if symptoms are present, an incisional hernia may be associated with major morbidity, loss of time from productive employment, and diminished quality of life.[1] Given the financial cost of incisional hernia repair and the disappointing recurrence rates up to 45%,[4,8] incisional hernia remains a significant challenge for most surgeons.

A number of factors associated with incisional hernia have been identified, some of which are local, such as wound infection and surgical technique,[2,9] and some, systemic, such as older age, male sex, and altered collagen metabolism.[5,10] In addition, a lifestyle factor like obesity has been found to be associated with incisional hernia.[5,11,12] Based on a previous study where we identified smoking as an independent predictor of inguinal hernia recurrence,[13] we hypothesized that smoking is associated with incisional hernia following laparotomy. Thus, the aim of this study was to identify and assess factors predictive of incisional hernia when adjusting for potential confounders through multiple logistic regression analysis.

METHODS

From January 1997 through December 1998, a total of 1066 elective and emergency laparotomies and relaparotomies were performed in 916 patients. The operations were performed at the Department of Surgery, Bispebjerg Hospital, Copenhagen, Denmark, and included open gastroduodenal, biliary, and pancreatic surgery as well as operations on the small bowel, colon, and rectum. In October 2001 (ie, 33-57 months following laparotomy), a clinical examination for incisional hernia was conducted. All patients alive at the time of follow-up were eligible for clinical examination except those who were lost to follow-up.

Data on variables related to the patient history, characteristics of the disease, preoperative clinical condition, operative severity and

Table 1. Patient Characteristics at the Time of Laparotomy*

Variable	Elective Surgery (n = 165)	Emergency Surgery (n = 145)	*P* Value†
Anamnestic variables			
Age, y, median (interquartile range)	66 (56-76)	63 (52-75)	.10
Male sex	76 (46.0)	65 (44.8)	.92
Family status, single or widow	74 (44.8)	59 (40.7)	.53
Employed	41 (24.8)	40 (27.6)	.68
Dependent functional status	10 (6.0)	15 (10.3)	.24
Daily smoker‡	68 (41.2)	62 (42.8)	.87
Ex-smoker§	52 (31.5)	37 (25.5)	.30
Alcohol abuser (more than 5 drinks per day)	7 (4.2)	13 (9.0)	.22
Body mass index, kg/m^2, median (SD)	25.6 (5.1)	24.5 (4.0)	.11
Diabetes, cardiovascular disease, or lung disease	63 (38.2)	58 (40.0)	.83
Liver cirrhosis, previous myocardial infarction, or stroke	10 (6.1)	13 (9.0)	.45
Hard labor, constipation, COPD, or prostate hypertrophy‖	45 (27.2)	44 (30.3)	.63
Physiologic variables			
Systolic blood pressure (<100 or >170 mm Hg)	21 (12.7)	15 (10.3)	.64
Pulse (>81 or <50 beats/min)	65 (39.4)	57 (39.3)	1.00
Electrocardiogram (not sinus rhythm)	9 (5.4)	10 (6.9)	.77
Impaired sensorium (Glasgow Coma Scale score <15)	2 (1.2)	4 (2.8)	.57
Hemoglobin (<10.95 g/dL or >16.43 g/dL)¶	47 (28.5)	43 (29.7)	.92
Leukocyte count (<4.0 × 10^3/μL or >10.1 × 10^3/μL)¶	15 (9.1)	82 (56.6)	<.01
Potassium level (<3.5 mEq/L or >5.0 mEq/L)¶	19 (11.5)	40 (27.6)	<.01
Sodium level (<135 mEq/L)¶	11 (6.7)	33 (22.8)	<.01
Creatinine level (>1.41 mg/dL)¶	7 (4.2)	15 (10.3)	.05
Operative variables			
Biliary surgery	37 (22.4)	21 (14.4)	.10
Gastroduodenal surgery	5 (3.0)	28 (19.3)	<.01
Small-bowel surgery	19 (11.5)	57 (39.3)	<.01
Colorectal surgery	103 (62.8)	38 (26.2)	<.01
Operative severity (difficult or very difficult)	79 (48.1)	64 (44.1)	.59
Multiple procedures	13 (7.9)	14 (10.0)	.73
Blood loss (>100 mL)	122 (7.4)	85 (58.6)	.01
Transfusions	34 (20.6)	23 (15.9)	.35
Peritonitis (local or diffuse)	5 (3.0)	44 (30.3)	<.01
Malignancy	71 (43.0)	18 (12.4)	<.01
Specialist surgeon	73 (44.2)	34 (23.4)	<.01
Postoperative variables			
Relaparotomy#	6 (3.6)	10 (6.9)	.30
Wound infection	12 (7.3)	32 (22.1)	<.01
Wound or fascial rupture	1 (0.6)	11 (7.6)	<.01

Abbreviation: COPD, chronic obstructive pulmonary disease.
SI conversion factor: To convert creatinine to micromoles per liter, multiply by 88.4.
*Values are expressed as number (percentage) of patients unless otherwise indicated.
†Mann-Whitney test or χ^2 test (2-sided).
‡Patients smoking on a daily basis at the time of surgery and at follow-up.
§Patients who stopped smoking sometime prior to surgery and remained abstinent since.
‖Data obtained at follow-up.
¶Values deviating from reference interval.
#Secondary operation performed within 30 days after laparotomy.

findings, and the surgeon's training were recorded prospectively in a clinical database.[14] Data regarding patient history (family, employment and functional dependent status, smoking and drinking habits, and comorbidity [defined as a medical disease in current treatment]) were collected from questionnaires completed prior to surgery by the patient or surgeon at hospital admission or at referral to the outpatient clinic. These data and data from the operation and clinical record were recorded on a database sheet by the surgeon preoperatively or postoperatively except data on transfusions, which were extracted from the local blood bank facility.

Postoperative complications occurring within 30 days after surgery were recorded by the surgeon at hospital discharge or at readmission. In case of admission to other departments of the hospital within 30 days, relevant data were extracted from retrieved clinical records and hospital discharge letters. Thus, only complications requiring hospitalization were recorded.

The data were entered in the database using EPI-INFO 6.0 software (Centers for Disease Control and Prevention, Atlanta, Ga). Data entry for all patients was ensured by continual control procedures.[14] Subsequently, the database was validated manually by matching the data with the clinical record of each patient.

At follow-up, additional supplementary data not recorded in the database were obtained from the clinical record such as height and weight, fascial closure, and localization of incision. We obtained a detailed smoking history from the patient to validate the smoking data recorded at the time of surgery, as well as indications of increased intra-abdominal pressure (hard la-

bor or treatment for chronic obstructive lung disease, constipation, or prostate hypertrophy). If the clinical examination disclosed an incisional hernia, data regarding discomfort, pain, and treatment were recorded. An incisional hernia was defined as a palpable defect of the fascia under or adjacent to an incision of the abdominal wall with a protrusion of tissue through the defect on Valsalva maneuver. Thus, this definition included parastomal hernia.

The analysis was performed as a multiple logistic regression analysis using SPSS 10.0 software (SPSS Inc, Chicago, Ill). Incisional hernia recorded at follow-up was the dependent variable. First, a univariate analysis was performed with patient age and sex as fixed covariates. Based on this model, the odds ratio of each variable listed in **Table 1** was estimated. Second, a forward selection procedure was carried out where variables likely associated with incisional hernia ($P \leq .20$) were included in a multivariate model. In this model, all variables not significantly associated with hernia ($P > .05$) were discarded by a backward elimination procedure. Finally, test results for linearity and interaction terms between variables were examined. All results were described with odds ratios and 95% confidence intervals.

To test for any selection bias in the material, a "dropout" and "best case/worst case" analysis was performed including all patients eligible for follow-up. Level of statistical significance was $P \leq .05$.

RESULTS

Three hundred ten patients were examined; 491 patients (53.5%) died before examination, 22 patients (2.4%) were lost to follow-up, and 93 patients (10.1%) failed to meet for examination. The incidence of incisional hernia was 26% (81/310). In 85% (66/81), the hernia was located in a midline incision ($P < .05$). An existing ostomy or sutured ostomy wound was present in 6% (18/310), in which 6 patients had a parastomal or incisional hernia. All fascial closures were made with absorbable suture (Vicryl 0-0; Ethicon, Johnson & Johnson Intl, St Stevens-Woluwe, Belgium) using a continuous or interrupted suture technique.

The median span from operation to an incisional hernia becoming symptomatic was 3 months (interquartile range, 2-6), and in 74% (60/81), the hernia occurred within the first year after laparotomy. Forty-nine percent (40/81) had discomfort or pain, and 25% (19/81) used a corset or an abdominal binder. Incisional hernia repair was performed in 23% (17/81).

Data recorded in the database related to patient history, preoperative clinical condition, operative severity and findings, and postoperative complications with a possible relation to incisional hernia are listed in Table 1. Overall, the results showed that patients who had been operated on electively were largely operated on by specialist surgeons, had malignant colorectal disease, experienced a larger blood loss, and had fewer postoperative wound complications (Table 1). In contrast, the patients operated on emergently mainly underwent gastroduodenal or small-bowel surgery, were in poor preoperative clinical condition with abnormal blood values and peritonitis, and had a high incidence of postoperative wound complications (Table 1).

The multiple regression analysis disclosed that older age, male sex, daily smoking, postoperative wound complication, and relaparotomy were independently associated with incisional hernia (**Table 2**). No significant interaction between postoperative wound complications and smoking or wound complications and relaparotomy were found. Neither emergency surgery nor conditions associated with increased intra-abdominal pressure were independent predictors of incisional hernia.

Table 2. Variables Associated With Incisional Hernia Following Laparotomy: The Final Model*

Variable	Univariate OR (95% CI)	Multivariate OR (95% CI)
Age, y†	1.03 (1.01-1.05)	1.04 (1.02-1.06)
Sex		
Female	1	1
Male	2.41 (1.42-4.10)	2.17 (1.21-3.91)
Smoking status		
Never smoker	1	1
Ex-smoker‡	1.44 (0.65-3.19)	1.57 (0.81-3.64)
Daily smoker§	3.48 (1.70-7.13)	3.93 (1.82-8.49)
Relaparotomy		
No	1	
Yes	4.65 (1.59-13.64)	5.89 (1.78-19.48)
Postoperative wound complication		
No	1	1
Yes	4.25 (2.24-8.08)	3.91 (1.99-7.66)
Alcohol consumption, drinks per day		
<5	1	
≥5	1.83 (1.13-2.96)	
Creatinine level, mg/dL‖		
≤1.41	1	
>1.41	3.69 (1.51-9.06)	
Operative severity		
Normal	1	
Difficult or very difficult	1.19 (1.04-1.36)	

Abbreviations: CI, confidence interval; OR, odds ratio.

SI conversion factor: To convert creatinine to micromoles per liter, multiply by 88.4.

*Three hundred eleven cases were included in the model; no cases were rejected because of missing data. Hosmer-Lemeshaw goodness-of-fit test $P = .90$.

†Continuous variable.

‡Patients who stopped smoking sometime prior to surgery and remained abstinent since.

§Patients smoking on a daily basis at the time of surgery and at follow-up.

‖Values deviating from reference interval.

A dropout analysis of patients eligible for follow-up disclosed that the examined patients had a higher prevalence of risk factors associated with incisional hernia (**Table 3**). No significant changes in the estimates of the multivariate analysis were found when performing a best case/worst case analysis, testing for selection bias owing to a hypothetical difference in the incidence of incisional hernia between patients who were examined and those who were not.

COMMENT

This study demonstrates that smokers have a 4-fold higher risk of incisional hernia than nonsmokers, independent of confounders and risk factors previously recognized to be associated with incisional hernia.[2,5,11]

Table 3. Dropout Analysis of 403 Patients Eligible for Follow-up*

Variable	Examined (n = 310)	Not Examined (n = 93)	*P* Value†
Age, y, median (interquartile range)	65 (53-76)	66 (48-81)	.59
Men	141 (45.5)	31 (33.3)	<.05
Daily smokers	125 (40.3)	46 (49.5)	.15
Wound complications	52 (16.8)	5 (5.4)	<.05
Relaparotomies	16 (5.2)	6 (6.5)	.80
Either male sex, daily smoking, wound complication, or relaparotomy	220 (71.0)	57 (61.3)	<.05

*Values are expressed as number (percentage) of patients unless otherwise indicated.
†Mann-Whitney test or χ^2 test (2-sided).

The majority of incisional hernia was in midline incisions and occurred during the first year after laparotomy, which confirms previous studies.[15] The incidence of incisional hernia in this study was higher than reported by others.[2-5] However, as a considerable number of incisional hernias are known to be asymptomatic,[3,16] the incidence found in this study may be owing to the long follow-up and the fact that all patients were physically examined by surgeons. In addition, parastomal hernias were included in our definition of incisional hernia, which may explain the high hernia rate because ostomies have been reported as being associated with the formation of incisional hernia.[17]

Postoperative wound infection is a well-documented risk factor for early dehiscence of incisional wounds and fascia and for later development of incisional hernia.[2,5] The pathogenesis is related to proliferation of bacteria in a wound, which affects each process involved in healing leading to decreased collagen synthesis, decreased bursting strength of the abdominal wall, and an increased risk of dehiscence.[18-20]

Smokers have a higher risk of surgical site infections, dehiscence of tissue and wounds, and recurrence of groin hernia.[13,21-24] Following this study, incisional hernia may be added to the list.

The proportion of smokers with incisional hernia was high as reported by other studies of patients with abdominal-wall hernia.[13,25] Several pathogenic mechanisms seem to be involved. Smoking and peripheral tissue hypoxia, which may be caused by smoking,[26,27] increase the risk of wound infection and dehiscence presumably through reduction of the oxidative killing mechanism of neutrophils, which constitute a critical defense against surgical pathogens.[28-30] In addition, decreased collagen deposition in surgical test wounds has been found in smokers,[31] a mechanism that may further attenuate the fascia in addition to the reduced collagen I–collagen III ratio present in incisional hernia.[10] Degradation of connective tissue caused by an imbalance between proteases and their inhibitors may also be responsible.[32] The latter mechanism, which is enhanced by smoking, is believed to cause tissue-destructive disorders like abdominal aorta aneurysm and pulmonary emphysema.[33-37] Both diseases are associated with abdominal-wall herniation.[38,39] In fact, the incisional hernia rate has been reported as high as 31% following midline laparotomy for abdominal aorta–aneurysm repair.[40,41]

In this study, a relaparotomy was the strongest predictor for incisional hernia. Reoperations have previously been found to increase the rate of abdominal wound dehiscence and may also be responsible for the development of incisional hernia.[42] Insufficient healing due to resuture of relatively nonvascular scar tissue of the fascia has been suggested.[43] In addition, patients undergoing relaparotomy are likely to have bacterial contamination of the wound and may in addition have peritonitis, which increase the risk of wound infection and delayed healing.[17]

Older age and male sex were independently associated with the development of incisional wall hernia, confirming other reports.[1,5,17,44] In both, delayed wound healing and decreased collagen synthesis may be involved.[45-47] Contrary to others, we did not find obesity to be associated with incisional hernia.[5,11,12]

The majority of the patients undergoing laparotomy died before follow-up. This relatively high mortality rate may be because the patient population was unselected and the hospital covers a central urban area with considerable social problems and drug and alcohol abuse. One may therefore question whether the examined patients are representative of a population undergoing laparotomy for gastrointestinal disease. Yet, in patients who survive their laparotomy by 2.5 years, we believe that our findings are representative supported on the fact that no selection bias was present.

In conclusion, smokers have a high risk of incisional hernia formation independent of other recognized risk factors, presumably owing to the detrimental effect of smoking on wound healing. This finding may encourage surgeons to advise patients to quit smoking prior to surgery. However, as the evidence of the effect of smoking cessation prior to surgery is conflicting,[21,48] long-term smoking-cessation intervention studies are needed to determine whether smoking cessation may reduce incisional herniation.

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Correspondence: Lars Tue Sørensen, MD, Department of Surgery K, Bispebjerg Hospital, Bispebjerg Bakke 23, DK-2400 Copenhagen NV, Denmark (lts@dadlnet.dk).
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