Effect of smoking on early complications after elective orthopaedic surgery

Ann M. Møller, Tom Pedersen, Nete Villebro, Anne Munksgaard

From Bispebjerg Hospital, Copenhagen, Denmark

Smoking is an important risk factor for the development of postoperative pulmonary complications after major surgical procedures. We studied 811 consecutive patients who had undergone hip or knee arthroplasty, recording current smoking and drinking habits, any history of chronic disease and such intraoperative factors as the type of anaesthesia and the type and duration of surgery. We recorded any postoperative complications occurring before discharge from hospital. There were 232 smokers (28.6%) and 579 non-smokers.

We found that smoking was the single most important risk factor for the development of postoperative complications, particularly those relating to wound healing, cardiopulmonary complications, and the requirement of postoperative intensive care. A delay in discharge from hospital was usual for those suffering a complication. In those patients requiring prolonged hospitalisation (>15 days) the proportion of smokers with wound complications was twice that of non-smokers.

J Bone Joint Surg [Br] 2003;85-B:178-81.
Received 30 July 2002; Accepted 26 September 2002

Arthroplasty of a major joint is a common surgical procedure in the elderly. It is associated with few serious complications, but when they occur they may be catastrophic and expensive.^{1,2} The major risk factors are advanced age, a history of cardiac or pulmonary disease and the type of surgery.³⁻⁸

Smoking is an important risk factor for the development of postoperative pulmonary complications after major surgical procedures and recent work has also associated smoking with wound complications and failure of bowel anastomoses.⁹⁻¹⁵ Our aim was to investigate the effect of smoking on the outcome after elective orthopaedic procedures, particularly the length of stay in hospital and the frequency of admission to intensive care.

Patients and Methods

We obtained the clinical records of 825 consecutive patients who had undergone hip or knee arthroplasty at Bispebjerg and Frederiksberg University Hospitals between January 1999 and December 2000. We excluded 14 patients whose notes did not record smoking habits, and whose follow-up had not been complete. The local Ethical Committee approved the study.

The data which were collected for each patient included age, gender, BMI, pre-existing cardiac, pulmonary or diabetic disease, physical classification (American Society of Anesthesiologists grade), type of surgery (hip or knee arthroplasty), type of anaesthesia (regional or general), the duration of surgery, the patients' weekly alcohol consumption (number of units), smoking habits (number of cigarettes, cheroots, cigars or pipes smoked daily, date when started or if stopped, when). The smoking status was recorded as pack years (daily consumption x number of years smoking ÷ 20). The patients were divided into current smokers, who smoked at least once a day (232), and non-smokers who had either never smoked (454) or had stopped (125).

Information concerning the type and duration of the anaesthesia and the surgical procedure undertaken was taken from the operating-theatre records. The patients received hydration intravenously (7.5 ml/kg/hour) throughout surgery, and at a rate of 3.5 ml/kg/hour for the first 24 hours after surgery, because hypovolaemia is known to decrease perfusion of the wound and increase the incidence of infection. Inspired oxygen was given at 80% during the operation and at 100% before extubation in order to reduce the incidence of wound infection.¹⁶ While in the recovery room, oxygen was given to maintain an oxyhaemoglobin saturation of at least 92%. Either a crystalloid solution

A. M. Møller, MD
T. Pedersen, MD
N. Villebro, RN
Department of Anaesthesiology
Bispebjerg University Hospital, Copenhagen NV 2400, Denmark.

A. Munksgaard, MD
Department of Anaesthesiology
Frederiksberg Hospital, Copenhagen.

Correspondence should be sent to Dr A. M. Møller.

©2003 British Editorial Society of Bone and Joint Surgery
doi:10.1302/0301-620X.85B2.13717 \$2.00

Table I. Details and smoking habits of the 811 patients scheduled for hip or knee arthroplasty

Characteristic	Smokers (n = 232)	Non-smokers (n = 579)	p value (two-tailed)
Mean ($\pm$ SD, range) age in years	68 $\pm$ 10 (30 to 94)	73 $\pm$ 10 (31 to 93)	<0.001
Gender			
M	79	199	0.93
F	153	380	
Mean ($\pm$ SD, range) (kg/m ²)	26 $\pm$ 5 (16 to 51)	27 $\pm$ 5 (15 to 57)	0.39
ASA physical-status score (% of patients)			
1 (healthy)	26	24	0.78
2 (minimal illness)	66	66	
2 (moderately ill)	8	10	
History of disease (%)			
Chronic heart disease	20	25	0.13
Chronic obstructive lung disease	12	7	0.04
Diabetes mellitus	8	4	0.005
Smoking habits			
Daily smoking (cigarettes/day $\pm$ SD; range)	14 $\pm$ 8 (1 to 40)		
Mean ($\pm$ SD, range) pack years (smoking years x daily consumption/20)	35 $\pm$ 17 (1 to 101)		
Alcohol consumption (units per week, %)			
<18	85	92	0.10
18 to 34	12	6	
>34	3	2	
Intraoperative factors (%)			
General anaesthesia	54	54	0.98
Knee replacement	28	34	0.16
Hip replacement	72	66	
Mean ($\pm$ SD, range) duration of surgery in minutes	89 $\pm$ 30 (35 to 210)	90 $\pm$ 35 (32 to 570)	0.68

(solution-to-blood-lost ratio of 4:1) or a colloid solution (solution-to-blood-lost ratio of 2:1) replaced any lost blood. The surgical procedures were routine and included a standard technique for wound closure using continuous sutures for the deep layers, interrupted sutures for subcutaneous tissues and staples for the skin. All patients received routine antibiotic and anti-thromboembolic prophylaxis.

Assessors (AM, TP), blinded as to the patients' risk factors, recorded all complications during the stay in hospital. We defined postoperative complications as either mortality or morbidity requiring treatment within four weeks of the operation.

The cardiopulmonary complications included congestive heart failure with bilateral râles, pulmonary oedema or left-sided heart failure documented by radiological changes, cardiac arrest and acute myocardial infarction. Acute myocardial infarction was defined by at least one of the following: development of new Q waves, new persistent ST-segment or T-wave changes, an elevation of total creatine kinase and creatine kinase MB isoenzyme values, pulmonary failure with pneumonia (fever, abnormalities on chest radiograph or positive sputum culture), or respiratory insufficiency requiring treatment.¹⁷

Only when bacteria were cultured from a wound was it considered to be infected.¹⁸ Other complications included

haematoma requiring drainage due to subfascial involvement, loosening of the prosthesis, infection of the urinary tract requiring antibiotic treatment, deep-venous thrombosis, gastrointestinal bleeding and postoperative confusion requiring medication. Information about admission to the intensive care unit (ICU) and the complication(s) leading to it were recorded. Finally, we recorded the duration of the stay in hospital.

We examined the pre- and postoperative variables in two-way tables (two-tailed chi-squared test); a value less than 0.05 was taken to be significant. Other results were evaluated by unpaired *t*-tests or Mann-Whitney U tests, as appropriate. All p values were two-sided. A multiple logistic regression analysis (controlled for potential confounders) was used to estimate the odds ratio (OR) of wound infection, ICU admission and postoperative complications. For statistical analysis we used SPSS software (version 10.0) (SPSS, Chicago, Illinois).

Results

Table I gives details of the patients' smoking habits. The smoking group was significantly younger than the non-smoking group ($p < 0.001$), and the incidence of diabetes mellitus and chronic obstructive lung disease was higher in

Table II. The outcome according to smoking habits for 811 patients scheduled for hip or knee arthroplasty, by number and *percentage*

Characteristic	Smokers (n = 232)	Non-smokers (n = 579)	p value
Cardiopulmonary insufficiency	13 (6)	15 (3)	0.03
Congestive heart failure	6 (3)	10 (2)	
Cardiac arrest	2 (1)	0 (0)	
AMI	2 (1)	2 (0.3)	
Respiratory failure	2 (1)	3 (0.5)	
Renal insufficiency	1 (0.4)	2 (0.3)	0.86
Delirium/confusion	11 (5)	14 (2)	0.08
Wound-related complications	53 (23)	47 (8)	<0.001
Haematoma	17 (7)	14 (2)	
Infection (positive culture)	32 (14)	32 (6)	
Subfascial collection	4 (2)	1 (0.2)	
Urinary tract infection	17 (7)	31 (5)	0.28
Total complications	84 (36)	114 (20)	<0.001
Death	1 (0.4)	1 (0.2)	0.50
Secondary revision surgery	15 (6)	14 (3)	0.03
Mean ($\pm$ SD; range) duration of hospitalisation (days)	14.3 $\pm$ 7.1 (7 to 66)	14.5 $\pm$ 7.1 (5 to 134)	0.77
Admission to ICU (%)	9 (4)	4 (0.7)	<0.001
Total number of days in ICU (%)	46 (1.4)	31 (0.4)	<0.001

the smoking group ($p < 0.005$ v $p < 0.04$). There was no difference in the characteristics of the patients or postoperative complications between the two hospitals.

Table II shows the postoperative complications in the two groups. The smokers had a significantly higher risk of developing some complications ($p < 0.001$); the greatest difference was seen in wound-related complications. They also had a higher risk of cardiopulmonary complications and of requiring ($p < 0.03$) further surgery. More smokers were admitted to the ICU postoperatively, and they spent a total of 46 days in the ICU compared with 31 days for the non-smokers (1.4% v 0.4%; days in ICU/number of days in hospital, $p < 0.001$).

Multivariate analysis was used to calculate factors associated with the development of postoperative complications (Table III). Compared with perioperative risk factors, smokers were at greater risk of developing wound-related complications (OR = 3.2), of requiring ICU admission (OR = 8.5) and, indeed, any complication. Arthroplasty of the knee was particularly associated with wound complications (OR = 2.4) and congestive heart failure with a variety of complications (OR = 1.7). Alcohol consumption (≥ 18 units per week) was also associated with wound-related complications (OR = 1.7), and age more than 70 years (OR = 5.6) was associated with admission to the ICU, although these two factors did not reach statistical significance. No other perioperative variables were associated with outcome.

Table III. Predictors of wound-related complications, admission to ICU and any postoperative complication in patients undergoing hip or knee arthroplasty

Predictors	Odds ratio	95% CI	p value
Wound-related complications			
Smoking	3.2	1.8 to 6.0	0.001
Knee arthroplasty	2.4	1.3 to 4.5	0.004
Alcohol ≥ 18 units per week	1.7	0.9 to 3.3	0.09
ICU admission			
Smoking	8.5	1.6 to 46.7	0.01
Age ≥ 70 years	5.6	0.6 to 50.0	0.12
Any complication			
Smoking	2.4	1.4 to 3.8	0.001
Congestive heart failure	1.7	1.0 to 2.9	0.04
Knee arthroplasty	1.6	0.9 to 2.7	0.06

Table IV. Number of patients who required prolonged hospitalisation (>15 days) after surgery and the presence of wound infection and any postoperative complication in smokers and non-smokers, by number and *percentage*

Characteristic	Smokers (n = 61)	Non-smokers (n = 171)	p value
Wound-related complications	23 (38)	32 (19)	0.003
Any postoperative complication	36 (59)	71 (42)	0.02

The mean length of stay in hospital was similar in the two groups, 14.3 days (7 to 66) for smokers) and 14.5 days (5 to 134) for non-smokers, but smokers with wound complications had an extended length of stay in hospital (18.2 v 14.4 days for the total study group; $p < 0.001$) as did smokers with any complication (17.4 v 14.5 days for the total study group; $p < 0.001$). For those who were required to stay in hospital for more than two weeks, the number of smokers with wound complications was double that of non-smokers (38% v 19%). The number of smokers with any postoperative complication was significantly higher than the number of non-smokers ($p = 0.02$; Table IV).

Discussion

These results indicate that smoking is the single most important risk factor for the development of complications after elective arthroplasty of the hip or knee. This is true whether we consider all complications, cardiopulmonary complications or those of wound healing, the risks of further surgery or the need for admission to ICU. There may be many reasons for this, some due to the association between smoking and chronic systematic disease such as atherosclerosis, diabetes mellitus or chronic obstructive lung disease.¹⁹⁻²² Smoking has recently been shown to be associated with impaired wound healing, and it has an effect on the immune system.²³⁻²⁷ This seems to be confirmed by our study which showed that wound complications were related to smoking habits. We also found that smokers were more likely to require further surgery, which may be related not only to impaired wound healing and infection, but to

impaired healing of bone, which has been recorded in dental and spinal surgery.²⁸⁻³⁰

In our patients, the smokers presenting for surgery were approximately five years younger than their non-smoking counterparts. In a previous study we found that the same was true for patients admitted to ICU after surgery.³¹ The reasons for this are not known, but there is some evidence that smoking accelerates the ageing processes, not only in the cardiovascular and pulmonary systems, but also in the musculoskeletal system.³²

Another important finding of our study was the extended length of stay in hospital for smokers with postoperative complications. For those with wound complications the mean length of hospital stay was prolonged by about four days and for those with any complication the corresponding figures are similar (three days). The occurrence of complications is also important for health-care economics as an extended stay in hospital, treatment in ICU, prolonged antibiotic therapy and secondary surgery are all expensive.

In an earlier study we showed that it is possible to reduce the incidence of postoperative complications by persuading patients to stop smoking some time before surgery.³³ Our findings have shown that smoking is the single most important risk factor for the development of serious postoperative complications in patients undergoing elective hip and knee arthroplasty.

We are indebted to the Chairpersons of the Orthopaedic Departments of Bispebjerg, and Frederiksberg University Hospitals in Copenhagen, Denmark for allowing us to include their patients in our study. The study was supported by grants from the Danish Research Councils, the Danish Ministry of Health and Director Danielsen's Foundation.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References

- Bennett-Guerrero E, Welsby I, Dunn TJ, et al. The use of a post-operative morbidity survey to evaluate patients with prolonged hospitalisation after routine, moderate-risk, elective surgery. *Anest Analg* 1999;89:514-9.
- Warner DO. Preventing post-operative pulmonary complications: the role of the anesthesiologist. *Anesthesiology* 2000;92:1467-72.
- Goldman L, Caldera DL, Nussbaum SR, et al. Multifactorial index of cardiac risk in noncardiac surgical procedures. *N Engl J Med* 1977;297:845-50.
- Mangano DT. Perioperative cardiac morbidity. *Anesthesiology* 1990;72:153-84.
- Mangano DT, Layug LL, Wallace A, Tateo I. Effect of atenolol on mortality and cardiovascular morbidity after noncardiac surgery. *N Engl J Med* 1996;335:1713-20.
- Brooks-Brunn JA. Predictors of post-operative pulmonary complications following abdominal surgery. *Chest* 1997;111:564-71.
- Priebe H. The aged cardiovascular risk patient. *Br J Anaesth* 2000;85:763-78.
- Dupuis J, Wang F, Nathan H, et al. The cardiac anaesthesia risk evaluation score. *Anesthesiology* 2001;94:194-204.
- Trayner E Jr, Celli BR. Post-operative pulmonary complications. *Med Clin North Am* 2001;85:1129-39.
- Moore LK. Smoking and post-operative pulmonary complications: an evidence-based review of the recent literature. *Clin Chest Med* 2000;21(1):139-46.
- Wattersley J, Hansen EG, Kamp-Jensen M, Roikjaer O, Kanstrup IL. PaO₂ during anaesthesia and years of smoking predict late post-operative hypoxemia and complications after upper abdominal surgery in patients without preoperative cardiopulmonary dysfunction. *Acta Anaesthesiol Scand* 2000;22:9-16.
- Ridderstolpe L, Gill H, Granfeldt H, Ahlfeldt H, Rutberg H. Superficial and deep sternal wound complications: incidence, risk factors and mortality. *Eur J Cardiothorac Surg* 2001;20:1168-75.
- Hussey LC, Hynan L, Leeper B. Risk factors for sternal wound infection in men versus women. *Am J Crit Care* 2001;10:112-6.
- Sorensen LT, Jorgensen T, Kirkeby LT, et al. Smoking and alcohol abuse are major risk factors for anastomotic leakage in colorectal surgery. *Br J Surg* 1999;86:927-31.
- Kasperk R, Philipps B, Vahrmeier M, Willis S, Schumpelick V. Risk factors for anastomosis dehiscence after very deep colorectal and colanal anastomosis. *Chirurg* 2000;71:1365-9.
- Grief R, Akca O, Horn E-P, Kurz A, Sessler DI. Supplemental peri-operative oxygen to reduce the incidence of surgical-wound infection. *N Engl J Med* 2000;342:161-7.
- Mangano DT, Browner WS, Hollenberg M, et al. Association of peri-operative myocardial ischemia with cardiac morbidity and mortality in men undergoing noncardiac surgery: the study of perioperative ischemia research group. *N Engl J Med* 1990;323:1781-8.
- Kurz A, Sessler DI, Lenhardt R. Perioperative normothermia to reduce the incidence of surgical-wound infection and shorten hospitalisation. *N Engl J Med* 1996;334:1209-15.
- Tegos TJ, Kalodiki E, Sabetai MM, Nicolaides AN. The genesis of arteriosclerosis and risk factors: a review. *Angiology* 2001;52:89-98.
- Evans WE, Hayes JP, Vermillion BD. Arteriosclerosis in the younger patient: results of surgical management. *Am J Surg* 1987;154:225-9.
- Fraser KL, Chapman KR. Chronic obstructive pulmonary disease: prevention, early detection, and aggressive treatment can make a difference. *Postgrad Med* 2000;108:103-10,113-6.
- Roche N, Huchon GJ. Current issues in the management of chronic obstructive pulmonary diseases. *Respirology* 1997;2:215-29.
- Abidi NA, Dhawan S, Gruen GS, Vogt MT, Conti SF. Wound-healing risk factors after open reduction and internal fixation of calcaneal fractures. *Foot Ankle Int* 1998;19:856-61.
- Scabbia A, Cho KS, Sigurdsson TJ, Kim CK, Trombelli L. Cigarette smoking negatively affects healing response following flap debridement surgery. *J Periodontol* 2001;72:43-9.
- Hunt TK, Hopf H, Hussain Z. Physiology of wound healing. *Adv Skin Wound Care* 2000;13(2 suppl):6-11.
- Kotani N, Hashimoto H, Sessler DI, et al. Smoking decreases alveolar macrophage function during anaesthesia and surgery. *Anesthesiology* 2000;92:1268-77.
- Bergmann KC. Effect of smoking on immune function. *Allerg Immunol (Leipz)* 1980;26:3-14.
- Glassman SD, Anagnost SC, Parker A, et al. The effect of cigarette smoking and smoking cessation on spinal fusion. *Spine* 2000;25:2608-15.
- Golosow LM, Wagner JD, Feeley M, et al. Risk factors for predicting surgical salvage of sternal wound-healing complications. *Ann Plast Surg* 1999;43:30-5.
- Jones JK, Triplett RG. The relationship of cigarette smoking to impaired intraoral wound healing: a review of evidence and implications for patient care. *J Oral Maxillofac Surg* 1992;50:237-9.
- Møller AM, Maaloe R, Pedersen T. Post-operative intensive care admittance: the role of tobacco smoking. *Acta Anaesthesiol Scand* 2001;45:345-8.
- Porter SE, Hanley EN Jr. The musculoskeletal effects of smoking. *J Am Acad Orthop Surg* 2001;9:9-17.
- Møller AM, Villebro N, Pedersen T, Tønnesen H. Effect of preoperative smoking intervention on postoperative complications: a randomised clinical trial. *Lancet* 2002;359:114-7.