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The efficacy of a smoking cessation programme in patients undergoing elective surgery – a randomised clinical trial

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Summary

It is known that smokers constitute an important risk group of patients undergoing surgery. It is unknown how smoking cessation intervention initiated 4 weeks prior to elective surgery affects the probability of permanent cessation. We randomly assigned 117 patients, scheduled to undergo elective orthopaedic and general surgery, to smoking cessation intervention and control group. The intervention group underwent a programme initiated, on average, 4 weeks prior to surgery with weekly meetings or telephone counselling and were provided with free nicotine replacement therapy (NRT). The control group received standard care. As a result, 20/55 (36%) patients the intervention group vs 1/62 (2%) in the control group became completely abstinent throughout the peri-operative period ($p < 0.001$). After 1 year, those in the intervention group was most likely to be abstinent (18/55 (33%) vs 9/62 (15%) of the controls ($p = 0.03$). Level of nicotine dependence and obesity seemed to be a predictor of long-term abstinence ($p = 0.02$).

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Smokers constitute an important risk group of patients prone to develop a range of postoperative complications including impaired wound and bone healing to life-threatening pulmonary and cardiovascular complications [1–7]. For these reasons, it is particularly important to find feasible, financially attractive, and effective means of pre-operative smoking cessation.

The success of an intervention programme is known to be affected by different patient-related factors. Low socio-economic status [8–10], high level of nicotine dependence [11–13], and having a partner who smokes [14, 15] are known predictors of failed smoking cessation. It seems that older age [16, 17] and a high body mass index [18, 19] (BMI) increase the probability of achieving abstinence. The intensity of the intervention programme also affects the success in smoking cessation [20, 21].

Some efforts have been aimed at optimising the pre-operative condition of smokers through smoking cessation intervention prior to planned surgery [22, 23], but there is still uncertainty about how long such interventions should last in order to reduce the risk of postoperative complications [24, 25].

In this study, the main aim was to investigate the short- and long-term efficacy of a pre-operative smoking cessation programme initiated 4 weeks pre-operatively and lasting 4 weeks following surgery. The second aim was to study how different patient-related characteristics affect the probability of long-term abstinence.

Patients and methods

The study was approved by the institutional review board at Karolinska Institute, Stockholm (Ref. No 03-214, 215;

Date: 2003.11.03) and was registered at Clinicaltrials.gov (NCT00533000). This randomised clinical trial was conducted at four university affiliated hospitals in Stockholm, Sweden. Between March 2004 – December 2006, active daily smokers (> 2 cigarettes per day during at least 1 year prior to inclusion), aged 18–79 years old, scheduled to undergo planned hip or knee arthroplasty, inguinal or umbilical primary hernia repair or laparoscopic cholecystectomy were invited to participate in this study. Current alcohol or drug abuse, pregnancy, severe mental illness, dementia or poor proficiency in the Swedish language were exclusion criteria. Patients were enrolled in the study by study nurses in the hospitals or by the treating surgeons after giving their informed consent, none of whom took part in the randomisation procedure.

Randomisation

Randomisation was made on the day of inclusion by the nurse providing smoking cessation. Patients were randomised in a 1 : 1 ratio to control or intervention groups, using opaque, sealed envelopes in blocks of 10, stratified by type of surgical procedure and the clinic. These envelopes were prepared by the nurse providing smoking cessation. The allocation was blinded to the treating physician and other medical staff. Patients in the intervention group were scheduled to undergo an intensive smoking cessation programme as described below and participants in the control group received standard care which meant brief or no information about smoking cessation prior to surgery.

Intervention

The smoking cessation programme was intended to start 4 weeks prior to planned surgery and lasted for 4 weeks following surgery. The intervention included weekly meetings or telephone counselling with a nurse professionally trained in smoking cessation therapy. Patients also received a telephone number for the national smoking cessation helpline in case they required further counselling or support. All participants in the intervention group were offered free nicotine replacement therapy (NRT) administered as self-adhesive patches, chewing gum or microtabs based on patient preferences. NRT was the only pharmaceutical cessation therapy offered. The main goal for patients in the intervention group was to be abstinent from smoking for a minimum of 3 weeks pre-operatively and for 4 weeks after surgery.

Recorded data

Each patient completed a self-administered questionnaire upon inclusion to the study, providing background information on patient-related, socioeconomic and lifestyle factors. BMI was calculated using the formula (weight (kg)/height^2 (m)). Obesity was categorised as BMI $\geq$ 30 kg.m^{-2} and BMI < 30 kg.m^{-2} was defined as not obese. The monthly average alcohol consumption was registered as 0–31 or $\geq$ 32 drinks per month. A standard glass of alcohol was considered as 15 centiliters (cl) of wine or 33 cl of beer or 4 cl of liquor. Tobacco use was categorised in pack years ((average daily cigarette smoking/20) $\times$ years of smoking) of smoking. The Fagerström Tolerance Questionnaire [26] was used to estimate patients' nicotine dependence. Information on regular exercise and snus (Swedish smokeless tobacco) use was registered. The participants' marital status, the smoking habits of their partners, level of education and occupational status was also registered. Pre-operative health evaluation provided the American Society of Anesthesiologists classification (ASA) [27]. The level of exhaled carbon monoxide (CO) (Micro^{TM} Smokerlyzer®, Bedfont Scientific Ltd, Rochester, UK) at the time of inclusion in the study and the presence of comorbidities were recorded. The Smokerlyzer measures CO in the range 0–200 with an accuracy of ±2%. Following inhalation, CO displaces oxygen in the erythrocyte to form carboxyhemoglobin. In this form, CO has a half-life of about 5–6 h and may remain in the blood for up to 24 h depending on a number of factors, such as gender, physical activity, and ventilation rate.

Outcome measures

For the intervention group, smoking status and tobacco consumption were recorded weekly during the intervention, either by face-to-face consultation or by telephone. In addition all patients answered a self-administered structured questionnaire about smoking habits and underwent a repeated CO measurement at a follow-up clinic 2–3 weeks postoperatively. Successful short-term abstinence was recorded only if participants reported no use of cigarettes at least 3 weeks prior to surgery, remained abstinent until 4 weeks after the surgery and if the level of exhaled carbon monoxide (CO) measured 2–3 weeks postoperatively, was ≤10 ppm.

To assess smoking status long-term, a questionnaire was sent to all participants 12 months following surgery. If the questionnaire was not completed and returned smoking data was retrieved by phone calls. Smoking status at 12 months was not validated.

Power calculation

The primary goal of this research project was to investigate the effect of peri-operative smoking cessation on the risk of postoperative complications, as published elsewhere [28]. The power calculation was based on previous studies [22, 23]. The baseline complication risk was set to be 30% and the treatment effect was estimated

to be a 30% reduction (from 30% down to 21%) in the risk of postoperative complications compared to the control group. Using a two-sided test, α-level of 0.05 and a statistical power of 80%, 586 patients were planned to be recruited. The recruitment ceased in December 2006 before the estimated number was met since the recruitment of patients had decreased. No interim analysis was performed.

Statistical analyses

Analyses were performed both according to intention to treat and by using per protocol information. Exclusions as shown in Fig. 1 were based on the primary outcome of postoperative complications reported elsewhere [28]. Most of those who where erroneously included, those who withdrew consent, or those who did not undergo surgery within the scheduled time frame, were not followed-up for their smoking status. All those patients with missing data on short- or long-term smoking status were considered to be smokers. The association between randomisation status and short and long-term abstinence from smoking were analysed using Fisher's exact test.

Multivariable logistic regression modelling was then used to study how the participants' characteristics could simultaneously affect the likelihood of abstinence one year following surgery. Variables were included in the multivariable model if the p value of the univariable analyses was $p < 0.15$. The results from the multivariable logistic regression analysis were presented as odds ratios (OR) using 95% confidence interval (CI). SPSS version 16.0.2 was used to perform the statistical analyses (SPSS, Chicago, IL, USA).

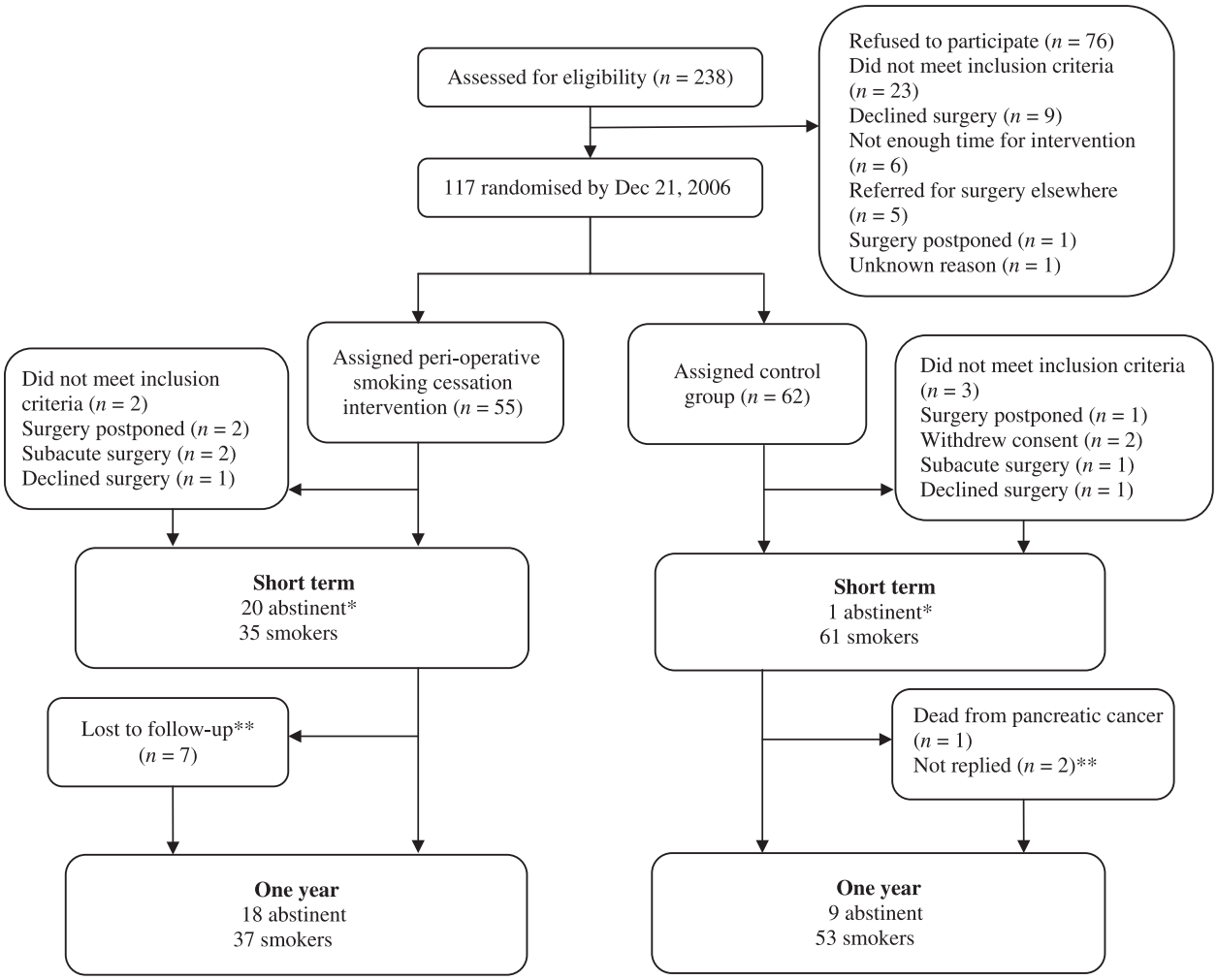

Figure 1 Trial profile. *Abstinence defined here by smoking zero cigarettes for a minimum period of 3 weeks prior to surgery until 4 weeks postoperatively with the additional criterion that the exhaled carbon monoxide level postoperatively did not exceed 10 ppm. **Lost to follow-up assumed to be smokers.

Results

Between February 2004 and December 2006, 117 patients were enrolled into the study. Information on smoking status was collected until January 2008. Seven patients in the intervention group and eight in the control group did not complete the study for reasons stated in Fig. 1. Five patients were incorrectly randomised since they did not meet the inclusion criteria (pipe smoker, cheroot smoker, bilateral hip prosthesis, bilateral knee prosthesis, and recurrent hernia). Data collection was only completed for those patients who followed the study protocol and their baseline characteristics are shown in Table 1. The smoking cessation programme started on average 4 (SD: 1.3) weeks prior to planned surgery and lasted for 4 weeks following the surgical procedure. Each patient in the intervention group participated in a mean of seven (SD: 1.8) meetings or telephone calls. Most patients, 41/48 (85.4%) patients in the intervention group used NRT products. No patient started using snus.

The short- and long-term success in abstinence achieved by both intention to treat and per protocol is shown in Table 2. According to the intention to treat analysis, 20 of 55 (36%) patients in the intervention group and one of 62 (2%) in the control group were completely abstinent for the minimum period of 3 weeks prior to surgery until 4 weeks following surgery ($p < 0.001$). Corresponding figures for the per protocol data were 19 of 48 (40%) and 1 of 54 (2%) ($p < 0.001$). Among those receiving the intervention in the per protocol analysis, the proportion of abstinent individuals increased from 40% 3 weeks before surgery to 58% the week before surgery.

Information on smoking status at one year was available for 48/55 patients (87%) of the intervention group and 52/62 (84%) of the control group. This information was retrieved on average 13 months (SD 2.8) following surgery. One death due to pancreatic cancer occurred in the control group 7 months after surgery. Long-term success rate in the intervention group was 18 of 55 (33%) compared to nine of 62 (15%) in the control group ($p = 0.03$). Corresponding values in the per protocol analysis was 17 of 48 (35%) and nine of 54 (17%) ($p = 0.04$).

Association between long-term abstinence according to the factors of baseline characteristics is shown in Table 3. At 1 year, in a multivariable model having a low nicotine dependence (Fagerström score < 4) and obesity (BMI ≥ 30 kg.m$^{-2)}$, were significantly associated with success in smoking cessation. No other factors were found to be significantly associated with successful abstinence 12 months after surgery.

Table 1 Baseline characteristics of patients according to the randomisation status.

	Randomisation status	
	Intervention (n = 48)	Control (n = 54)
Patient-related factors		
Male gender	30 (62%)	24 (44%)
Age, median (IQR*); years	55 (46–60)	57.5 (49–64)
ASA classification (1–2)	44 (92%)	46 (85%)
Alcohol use (< 32 drinks/month)	38 (79%)	45 (83%)
Body-mass index, median(IQR); kg.m^{-2}	26 (24–30)	25 (23–29)
Regular exercise	15 (31%)	23 (44%) (n = 52†)
Comorbidities		
Diabetes	0 (0%)	2 (4%)
Chronic heart disease	1 (2%)	8 (15%)
Chronic obstructive pulmonary disease or asthma	6 (13%)	6 (11%)
Depression	5 (10%)	10 (19%)
Smoking status		
Cigarettes per day, median (IQR)	15 (10–20)	15 (10–20)
Years of smoking, median (IQR)	34.5 (25–42)	36.5 (30–45) (n = 53†)
CO in exhaled air, median (IQR)	15.5 (8–22)	14 (8–20) (n = 53†)
Snus use	5 (10%)	4 (7%)
Fagerström score < 4	18 (38%)	19 (36%) (n = 53†)
Living with a smoker	21 (44%)	15 (28%) (n = 53†)
Socio-economic status		
Education at university level	9 (19%)	14 (27%) (n = 52†)
Employment	31 (65%)	31 (57%)
Married or having a partner	32 (67%)	31 (58%)

*Interquartile range.
†Missing data makes n differ from 54.

Table 2 Abstinence at different points of follow-up as a result of allocation status.

	Randomisation status		
Abstinence	Intervention, n (%)	Control, n (%)	p value
Peri-operative* – intention-to-treat†	20/55 (36)	1/62 (2)	< 0.001
Peri-operative* – per-protocol	19/48 (40)	1/54 (2)	< 0.001
One year after surgery – intention-to-treat†	18/55 (33)	9/62 (15)	0.03
One year after surgery – per-protocol†	17/48 (35)	9/54 (17)	0.04

*Abstinence defined here by smoking zero cigarettes for a minimum period of 3 weeks prior to surgery until 4 weeks postoperatively with the additional criterion that the exhaled carbon monoxide level postoperatively did not exceed 10 ppm.
†Lost to follow-up assumed to be smoker.

Discussion

This study demonstrates that successful smoking cessation can be achieved by an intervention programme initiated only 4 weeks prior to planned surgery. This result is in agreement with that from Moller et al. [22] where pre-operative smoking cessation was introduced 6–8 weeks prior to planned hip and knee arthroplasty. The importance of this finding is that many surgical conditions do not allow 6–8 weeks of pre-operative intervention. Also, a shorter period of intervention is more feasible to perform and is less expensive. Our intervention was also highly effective in reducing post-operative complications, the overall complication rate in the control group was 41% and in the intervention group it was 21% ($p = 0.03$) [28].

The rate of smoking cessation in the current study was consistent with other studies investigating smoking cessation in conjunction with surgery [29–33]. Therefore, a forthcoming surgical procedure could act as a 'teachable moment' and modify the patient's life-style to a healthier one. Yet, the life-style modifying effect of surgery seems to fade with time and abstained smokers tend to relapse. Among those receiving the intervention, 58% were abstinent the week before surgery. At 1 year this proportion decreased to 35%. Knowing that only 3–5% of smokers stop smoking spontaneously and remain abstinent 6–12 months following a given cessation attempt [34], it appears that a highly intensive intervention as in the current study could be efficient to increase the probability of becoming abstinent in the long-term.

The level of nicotine dependence significantly affected the likelihood of becoming abstinent one year following surgery. It has been proposed that nicotine dependence should be considered as a chronic disorder and longer periods of intervention may be necessary for some individuals to remain abstinent [35]. Hence, further investigations to find more tailored intervention approaches are required to maximize the effects of smoking cessation intervention to a larger group of smokers. The increased smoking cessation rate among obese patients has been suggested to be due to an increased health concern amongst overweight patients [18].

This study has some limitations. Smoking status one year after surgery was not verified by measurement of CO in the exhaled air. Lack of smoking status validation may overestimate the probability of abstinence one year after surgery. Moreover, this study was not primarily designed to investigate predictors of successful smoking cessation. Therefore, Table 3 must be interpreted with some caution due to the non-randomised nature of the data. Due to low rate of recruitment we had to terminate the study before the estimated number of study participants was recruited. Therefore given the small sample size some of the results could suffer from type II error and may be false-negative.

Finally the rate of refusal was high. Unwillingness to quit smoking and being stressed by the forthcoming surgery were the main two reasons for participation refusal. Recruitment to a randomised clinical trial often causes a self-selection of individuals from a population. Thus, there is a possibility that the resulting cohort in this

Table 3 Univariable and adjusted OR and their corresponding 95% CI for the association between abstinence 1 year after surgery and factors of baseline characteristics ($n = 102$).

	Univariable OR (95% CI)	p value	Adjusted OR (95% CI)	p value
Randomisation status				
Intervention group	2.7 (1.1–6.9)	0.03	2.5 (0.9–6.9)	0.08
Patient-related factors				
Male gender	1.6 (0.6–4.0)	0.31	–	–
Age (> 55 years)	0.8 (0.3–2.0)	0.65	–	–
ASA classification (1–2)	1.8 (0.4–8.9)	0.46	–	–
Alcohol use (< 32 drinks/month)	1.0 (0.3–3.0)	0.93	–	–
Obese (≥ 30 $kg.m^{-2}$)	2.6 (0.9–7.0)	0.07	3.3 (1.0–10.4)	0.04
Regular exercise	0.7 (0.3–1.7)	0.38	–	–
Comorbidities				
Chronic heart disease	1.5 (0.4–6.6)	0.57	–	–
Chronic obstructive pulmonary disease or asthma	2.3 (0.7–8.2)	0.18	–	–
Depression	0.2 (0.0–1.4)	0.10	0.1 (0.0–1.4)	0.10
Tobacco status				
Pack-years (> 30)	0.6 (0.2–1.5)	0.26	–	–
Snus use	0.3 (0.0–2.9)	0.32	–	–
Fagerström score < 4	2.6 (1.1–6.6)	0.04	3.4 (1.2–9.6)	0.02
Living with a smoker	0.9 (0.4–2.4)	0.90	–	–
Socio-economic status				
Education at university level	1.4 (0.5–4.0)	0.49	–	–
Employment	2.7 (1.0–7.5)	0.06	2.3 (0.7–7.1)	0.15
Married or having a partner	1.2 (0.5–3.0)	0.71	–	–

study consisted of motivated individuals who were more amenable to smoking cessation than smokers in general. Therefore, if applied to surgical patients undergoing similar surgical procedures as in the current study, the rates of smoking cessation will probably not be as high as in this study. However there is a considerable long-term health benefit for those who succeed.

In conclusion, this study demonstrates that a smoking cessation programme could be successfully instigated as late as 4 weeks before surgery with long lasting results. Therefore, the peri-operative period should be used by the health care personnel to encourage and support smoking cessation. The level of nicotine dependence is a predictor of long-term success in smoking cessation.

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Contributors

OSA and DL analysed the data. OSA and DL drafted the paper. All co-authors participated in the analyses and interpretation of data and contributed to subsequent drafts. AW is the guarantor.

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Role of sponsors

None of the funding sponsors took part in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript.

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