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Smoking Behavior and Perceived Stress in Cigarette Smokers Undergoing Elective Surgery

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Background: **The forced abstinence from cigarettes accompanying surgery in smoke-free facilities may increase psychological stress by removing a coping mechanism and by nicotine withdrawal. The authors tested the hypothesis that abstinence from cigarette smoking contributes to psychological stress in the perioperative period.**

Methods: **The authors assessed measures of nicotine withdrawal (Hughes-Hatsukami nicotine withdrawal scale) and perceived stress (including the Perceived Stress Scale) in 141 cigarette smokers scheduled to undergo elective surgery. To separate the effects of stress arising from tobacco abstinence from the effects of other perioperative stressors, such as pain, these measures were also obtained in 150 surgical patients who did not use tobacco. Assessments were performed at intervals beginning at the time of preoperative medical evaluation and ending 30 days postoperatively.**

Results: **Perceived Stress Scale scores were significantly ($P < 0.001$) higher in smokers throughout the study period. There was little significant interaction between smoking status and time, indicating that changes in Perceived Stress Scale score during the perioperative period did not differ between smokers and nonsmokers. The same result was found if analysis was restricted to data collected before hospital discharge (and thus during assured abstinence). Similar results were found for the nicotine withdrawal scale, suggesting that smokers did not experience more withdrawal symptoms relative to nonsmokers.**

Conclusions: **Although smokers report increased baseline stress, smoking status does not affect changes in perceived stress over the perioperative period. Nicotine withdrawal symptoms do not seem to be a clinically significant problem in the perioperative period for most smokers.**

APPROXIMATELY 23% of American adults are current cigarette smokers,[1] and many of these individuals undergo surgery and anesthesia. Current policies in most healthcare facilities prohibit smoking indoors or on the grounds of the facilities, so that all smokers undergoing surgery experience some period of forced abstinence. Smoking abstinence in surgical patients may reduce the perioperative complications associated with cigarette smoking and may also be a "teachable moment" or opportunity for patients to initiate a permanent cessation attempt.[2] However, abstinence may also present challenges for surgical patients.

Smoking can acutely reduce measures of stress,[3] and withdrawal from cigarettes is distressing to many smokers.[4] The experience of surgery itself can undoubtedly be stressful, and nicotine withdrawal may exacerbate this stress in smokers. A number of studies have found that perceived stress affects smoking behavior.[5–7] High stress levels experienced by patients in the perioperative period during forced abstinence may thus reduce the likelihood of prolonged cessation. For example, those patients who view smoking as a successful stress-reduction strategy may be eager to resume smoking after surgery. If so, then strategies such as nicotine replacement therapy to prevent stress associated with nicotine withdrawal symptoms may be of potential benefit. On the other hand, it is possible that in fact the stress of surgery itself mitigates the impact of nicotine withdrawal symptoms, making the perioperative period an ideal time to promote permanent cessation.

Another barrier to the formulation of strategies to promote smoking cessation in surgical patients is a dearth of information regarding their smoking behavior and attitudes toward cessation. Although there is much information regarding hospitalized patients[8] (usually without distinguishing between medical and surgical patients), there is no information regarding patients undergoing outpatient surgery, which now is more common than inpatient surgery. As a first step in developing nicotine-dependence treatments directed at this group of patients, it is important to obtain descriptive information on smoking behavior and attitudes toward cessation.

Our overall goal is to gain information that could inform about efforts to encourage smoking cessation in surgical patients. The primary aim of this study was to test the hypothesis that abstinence from cigarette smoking contributes to psychological stress in the perioperative period. We assessed measures of nicotine withdrawal and perceived stress in a cohort of cigarette smokers scheduled to undergo elective surgery at intervals beginning at the time of preoperative medical evaluation and ending 30 days postoperatively. To separate the effects of stress arising from tobacco abstinence from the effects of other perioperative stressors such as pain, these measures were also obtained in a control cohort of surgical patients who did not use tobacco.

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Another aim was to describe smoking behavior in the study period and attitudes of these smokers toward cessation.

Materials and Methods

This study was approved by the Mayo Clinic Institutional Review Board (Rochester, Minnesota).

Recruitment

All patients receiving preoperative medical examinations at the Mayo Clinic Rochester Preoperative Examination Center (POE) were eligible for enrollment. Approximately 20% of adult patients undergoing surgery at Mayo Clinic Rochester are evaluated in this facility in preparation for a wide variety of surgical procedures. This permits sampling of a general surgical population, although patients undergoing some categories of procedures (such as cardiac bypass surgery) are not represented.

This study examined two cohorts of participants: smoking and nonsmoking. A smoking history was obtained for each patient evaluated in the POE. Those patients having smoked one or more cigarettes each day within the preceding week were eligible for enrollment in the smoking cohort. If a patient did not participate, information regarding patient demographics and baseline smoking history (gathered as part of the standard clinical record) was noted for use in later analysis to determine how smokers who participated in the study may differ from smokers who did not participate. Information from those who did not enroll in the study was used only for patients who had given previous authorization to Mayo Clinic for use of their medical records for research (approximately 95% of patients). Patients were eligible for the nonsmoking cohort if they self-reported no cigarette or other tobacco use within the previous year and had smoked less than 100 cigarettes in their lifetime. An attempt was made by study personnel to match recruitment rates in both the nonsmoking and smoking groups.

After informed consent was obtained, each enrolled patient was stratified according to the type of planned anesthesia: (1) local anesthesia with sedation as an outpatient procedure (monitored anesthesia care [MAC]), (2) general or major regional anesthesia scheduled as an outpatient procedure (outpatient anesthesia), or (3) general or major regional anesthesia scheduled as an inpatient procedure (inpatient anesthesia). This stratification was chosen to define three categories of escalating procedural intensity, recognizing that this provides only a rough approximation.

Because of logistical constraints, not every potential patient was approached for enrollment, such that this procedure provided a convenience sampling of the total population of patients evaluated in the POE.

Procedure

Subjects in both cohorts were assessed twice preoperatively: at the time of enrollment in the POE (initial assessment) and on the morning of surgery (preoperative assessment). After surgery, the subjects were assessed on postoperative day (POD) 1 (defined as the day of surgery). This POD1 assessment was performed at the time of hospital discharge (for outpatients) or in the hospital ward after discharge from the postanesthesia care unit on the day of surgery (for inpatients). Assessments were also performed on days 2, 3, 8, and 30 postoperatively (POD2, POD3, POD8, and POD30, respectively). Postoperative assessments were performed in person (if the patients were still in the facility) or by telephone (if the patients were discharged). Postoperative assessments were only performed in inpatients if they were sufficiently awake to respond appropriately. To maintain consistency, all assessments were performed privately by study personnel using an interview format. Components of these assessments included the following.

Baseline Measures. Demographic information and comorbidity was abstracted from the medical record, with comorbid conditions such as hypertension defined according to standard criteria.[9] A baseline smoking history was administered, which included the Fagerström test for nicotine dependence (FTND).[10] Smokers were also queried to determine whether they would be interested in participating in a smoking cessation program in the perioperative period.

The stage of change[11] was assessed in smokers. Consistent with other studies conducted in a medical setting,[12,13] the staging questions were adapted to the perioperative period. If patients answered affirmatively to the question "Is it your plan to stay quit once you leave the hospital?" they were classified as being in the *action* stage. If they answered negatively to that question but answered affirmatively to the question "Do you plan to initiate a serious quit attempt within 30 days after you leave the hospital?" they were classified as being in the *preparation* stage. If they answered negatively to that question but answered affirmatively to the question "Do you plan to initiate a serious quit attempt within 6 months after you leave the hospital?" they were classified as being in the *contemplation* stage. If they answered negatively, they were classified as being in the *precontemplation* stage.

To determine whether smokers and nonsmokers have similar exposure to environmental stressors preoperatively that may affect their responses to surgical stress, the Life Experiences Survey was administered.[14] The Life Experiences Survey is a widely used 57-item self-report measure that asks respondents to indicate major stressors that they have experienced in the past 12 months.

Measures Obtained at All Assessments. The Minnesota Nicotine Withdrawal Questionnaire[15,16] was used to

assess nicotine withdrawal symptoms. This 8-item measure consists of the following symptoms rated on a five-point scale ranging from 0 (not present) to 4 (severe): desire to smoke; anger, irritability, or frustration; anxiety or nervousness; difficulty concentrating; impatience or restlessness; hunger; awakening at night; and depression. A composite nicotine withdrawal score (NWS) was computed as a mean of the eight items.

The 10-item Perceived Stress Scale (PSS)[17–19] was used as the primary outcome assessing psychological stress. Questions were asked in relation to experiences within the previous day. In addition to the PSS, we asked patients to rate their overall current stress on a subjective 11-point scale, with 0 representing no stress and 10 representing the worst stress imaginable, referred to as the numerical stress score (NSS). The validity of similar continuous ratings of stress have been demonstrated by their relation with standardized stress questionnaires, neuroendocrine, and physiologic measures of stress.[20–22] A numerical pain score (NPS)[23,24] for current pain at rest (from 0 [representing no pain] to 10 [representing the worst pain imaginable]) was also obtained.

In addition to the above measures, other information was gathered at some assessments. Self-reported smoking behavior was ascertained for the time since the last assessment, including the use of any nicotine replacement therapy. Expired carbon monoxide concentrations were obtained immediately preoperatively with a handheld device to confirm the smokers' recent smoking report. The attribution of the sources of perceived stress, including abstinence from smoking, was also surveyed at POD30, using a seven-point scale ranging from not stressful to extremely stressful.

Data Analysis

The primary analysis was performed using data collected during the immediate perioperative period (morning of surgery through POD 8). For the NWS, PSS, NSS, and NPS, the data were analyzed using general linear models that accommodate a varying number of observations for each individual and take into account the clustering of repeated assessments within individuals. For these models, a lag-1 autoregressive structure was used to model the covariance of repeated measures within individuals. To satisfy modeling assumptions, the analysis of PSS data, which have a positively skewed distribution, was performed using the square root of PSS as the dependent variable. For NPS and NSS, supplemental analyses were performed for the binary endpoints of any pain (NPS $>$ 0) and any stress (NSS $>$ 0). These analyses were performed using Generalized Estimating Equations with a logit link function and a lag-1 autoregressive structure to model the covariance of repeated measures within individuals.[25] Study cohort (smoker, nonsmoker), anesthesia category (MAC, outpatient, inpatient), and time (preop, POD1, POD2, POD3, POD8) were included in the model as classification variables, with main effects and all corresponding two-way and three-way interaction effects evaluated accordingly. The analyses were performed with anesthesia category classified according to the actual care the patient received, because in some patients, the actual care received differed from that planned at the time of the POE visit (*e.g.*, unplanned hospital admission in a scheduled outpatient). Whenever significant two-way or three-way interactions involving anesthesia category were detected, supplemental analyses were performed separately for each anesthesia category. In all cases, one analysis was performed using all data, and a second analysis was performed using only data collected from subjects while they were in the smoke-free hospital environment. Because age differed significantly between smokers and nonsmokers, each analysis was also repeated with age included as a covariate.

In addition to the above analyses comparing smokers and nonsmokers, a set of supplemental analyses was performed using only perioperative data collected from smokers while they were in the smoke-free hospital environment. These analyses were performed to assess whether NWS, PSS, NSS, or NPS differed among smokers according to level of nicotine dependence (treated categorically as FTND score $\leq$ 5 *vs.* FTND score $\geq$ 6)[10] or number of cigarettes smoked per day preoperatively (treated as a continuous variable). Additional analyses comparing demographic and smoking history variables between eligible smokers who participated in the study *versus* those who did not and comparing baseline characteristics of smokers *versus* nonsmokers were performed using analysis of variance or chi-square analysis as appropriate.

Other statistical methods (*e.g.*, rank sum test, signed-rank test, paired *t* test) were used where indicated. In all cases, two-tailed tests were used, with *P* values of 0.050 or less used to denote statistical significance.

Results

Study Population

Enrollment within each scheduled anesthesia category continued until 50 smokers and 50 nonsmokers were enrolled, with the exception of patients scheduled for MAC, which was the slowest category to accrue. Enrollment of patients scheduled for MAC was stopped at 41 smokers and 50 nonsmokers after determining that this decision would have a minimal effect on statistical power. The total enrollment period was 18.5 months, October 2000 to April 2001 (6.9, 17.3, and 18.5 months for inpatient, outpatient, and MAC, respectively). Of the 7,973 patients evaluated in the POE during this time, 999 (12.5%) were classified as current smokers according to the definition used in this study. Because enrollment was discontinued within each scheduled anesthesia category

Table 1. Baseline Demographics

Characteristic	Monitored Anesthesia Care		Outpatient		Inpatient	
	Nonsmoker (n = 48)	Smoker (n = 39)	Nonsmoker (n = 49)	Smoker (n = 45)	Nonsmoker (n = 53)	Smoker (n = 57)
Sex, No. (%)						
Male	24 (50)	21 (54)	24 (49)	25 (56)	25 (47)	34 (60)
Female	24 (50)	18 (46)	25 (51)	20 (44)	28 (53)	23 (40)
Age, yr	65.2 ± 14.5	54.8 ± 14.3	51.1 ± 18.3	46.1 ± 14.7	56.6 ± 14.8	49.5 ± 10.9
Body mass index	29.9 ± 7.3	28.6 ± 7.5	29.4 ± 6.7	27.7 ± 6.2	29.1 ± 5.6	28.5 ± 6.7
Days hospitalized	NA	NA	NA	0 ± 0	3.1 ± 2.5	3.2 ± 2.8
Insulin-dependent diabetes, No. (%)	0 (0)	0 (0)	2 (4)	0 (0)	0 (0)	0 (0)
Hypertension, No. (%)	12 (25)	10 (26)	10 (20)	2 (4)	16 (30)	12 (21)
Coronary artery disease, No. (%)	0 (0)	4 (10)	1 (2)	1 (2)	0 (0)	1 (2)
Asthma/chronic lung disease, No. (%)	3 (6)	2 (5)	2 (4)	5 (11)	3 (6)	1 (2)
Life Experiences Survey negative impact score	−3.1 ± 6.6	−3.3 ± 4.3	−4.2 ± 5.3	−5.6 ± 6.9	−5.6 ± 7.6	−5.5 ± 7.2

Continuous values are presented as mean ± SD.

NA = not applicable.

after 50 smokers were enrolled, not all of the smokers seen during the overall enrollment period were offered enrollment in the study. Of the 556 smokers to whom enrollment was offered, 141 (25%) enrolled. Comparing smokers who did and did not enroll, study participation was not found to depend on sex, age, time since last cigarette, cigarettes per day, stage of change, number of past cessation attempts, time since last cessation attempt, or longest duration of previous abstinence (data not shown). Therefore, we consider the smokers enrolled to be representative of the total population of smokers seen in the POE. Of the 150 nonsmokers enrolled, 145 (96.7%) had never smoked.

The majority of enrolled subjects (59%) underwent surgery on the day after their POE visit, and 95% underwent surgery within 14 days (maximum, 38 days). The time from POE to surgery did not differ between smokers and nonsmokers ($P = 0.938$, rank sum test). For 25 subjects (15 smokers, 10 nonsmokers), the anesthetic care received was different than that planned at the time of the POE visit. Most of these cases involved postoperative hospital admission of planned outpatients. Characteristics of the study sample are presented in tables 1 and 2 according to the actual care received. Within each category, the mean age of smokers and nonsmokers differed by approximately 10 yr, with nonsmokers being significantly older ($P < 0.001$). Other characteristics did not differ significantly between groups. In particular, the negative impact score of the Life Experiences Survey did not differ significantly between smokers and nonsmokers.

Among smokers, the average number of cigarettes smoked per day was 18.5 (range, 2–40), and 29% were classified as highly dependent on nicotine, defined as an FTND score of 6 or greater[10] (table 3). Most smokers (77%) had made at least one previous serious attempt to stop smoking, and 31% reported making a stop attempt in the previous 12 months. The majority (60%) of smokers who responded to the questions designed to assess stage of change for this study were classified as being in preparation or action stages (table 3). In addition, a majority of the smokers were interested in participating in a smoking cessation program if covered by insurance; interest lessened if the program was self-funded.

Perioperative Smoking Behavior

At the time of the POE visit, which is typically the last medical encounter before admission to the hospital for surgery, only 36% of enrolled smokers reported that they had been advised by any medical personnel to stop smoking before surgery. The majority of enrolled smokers smoked up to the time of hospital admission (table 4). Approximately 60% smoked within 2 h of admission, and only 9 (6.4%) had been abstinent for 24 h or longer. The preoperative carbon monoxide values were consistent with recent smoking before admission (table 4).

Table 2. Surgical Procedures

Procedure, No. (%)	Monitored Anesthesia Care (n = 88)	Outpatient (n = 93)	Inpatient (n = 110)
Ophthalmologic	45 (51)	14 (15)	4 (4)
Genitourinary/proctology	25 (28)	39 (42)	13 (12)
Plastic surgery/breast	5 (6)	5 (5)	4 (4)
Dental	4 (5)	16 (17)	0
Peripheral nerve	4 (5)	4 (4)	0
Angiogram	5 (6)	0	0
Orthopedic	0	15 (16)	11 (10)
Spine	0	0	30 (27)
Intraabdominal	0	0	27 (25)
Intracranial	0	0	10 (9)
Vascular	0	0	6 (5)
Otorhinolaryngologic	0	0	5 (5)

Table 3. Baseline Smoking Behavior

	Monitored Anesthesia Care (n = 39)		Outpatient (n = 45)		Inpatient (n = 57)	
	Median	Mean ± SD	Median	Mean ± SD	Median	Mean ± SD
Cigarettes per day	20.0	19.1 ± 10.6	20.0	18.7 ± 8.7	20.0	17.9 ± 9.9
FTND score, No. (%)	4.0	3.7 ± 2.3	4.0	4.1 ± 2.4	4.0	4.3 ± 2.0
< 6		30 (81)		28 (64)		37 (70)
≥ 6		7 (19)		16 (36)		16 (30)
No. of past cessation attempts, No. (%)						
0	6 (16)		12 (28)		13 (25)	
1	7 (18)		9 (21)		9 (17)	
2–5	16 (42)		15 (35)		27 (52)	
≥ 6	9 (24)		7 (16)		3 (6)	
Most recent cessation attempt						
Within the past year	13 (35)		13 (30)		15 (29)	
> 1 yr ago	24 (65)		30 (70)		37 (71)	
Duration of continuous abstinence during last cessation attempt						
< 1 day	10 (27)		14 (33)		17 (33)	
1–30 days	13 (35)		18 (43)		20 (38)	
1–5 months	7 (19)		3 (7)		6 (12)	
≥ 6 months	7 (19)		7 (17)		9 (17)	
Anyone at Mayo encouraged patient to not smoke after surgery, No. (%)	17 (47)		13 (32)		20 (39)	
Stage of change, No. (%)						
Precontemplation	4 (13)		17 (47)		8 (16)	
Contemplation	8 (27)		3 (8)		6 (12)	
Preparation	7 (23)		5 (14)		6 (12)	
Action	11 (37)		11 (31)		30 (60)	
Interested in insurance-covered smoking cessation program	19 (56)		25 (60)		41 (82)	
Interested in self-funded smoking cessation program	10 (29)		9 (21)		23 (48)	

Numbers of responses do not always add up to the number of subjects in each group because some subjects declined to answer some items. Percentages for items with multiple possible responses represent the percentage of subjects providing responses.

FTND = Fagerström test for nicotine dependence.

By definition, all patients in the MAC and outpatient groups left the hospital on the day of surgery (POD1). For the inpatient group, 31% of subjects (32% of smokers, 30% of nonsmokers) were discharged on the day after surgery (POD2), and an additional 26% (23% of smokers, 30% of nonsmokers) were discharged the following day. Few patients (7% of smokers, 10% of nonsmokers) were hospitalized for more than 7 days after their surgery.

The majority of smokers resumed smoking on the day of hospital dismissal, and more than 80% had resumed smoking within 3 days after discharge. At POD30, there were 26 subjects (18%) who indicated they were not smoking, of which 15 subjects (11%) self-reported being continuously abstinent since leaving the hospital. The percentage of patients continuously abstinent through POD30 was significantly higher for inpatients (12 of 57, 21%) compared with those having MAC (1 of 39, 3%; $P = 0.013$) or other outpatient procedures (2 of 45, 4%; $P = 0.020$). Of the 15 patients who self-reported continuous abstinence, 13 were classified as being in the action stage at the initial assessment (*i.e.*, stated that they planned to continue abstinence after surgery), and 2 were in the preparation stage. Thus, 13 of 52 patients (25%) in the action phase at the initial assessment reported being continuously abstinent through POD30. In contrast, no patients in precontemplation or contemplation stages and only 2 of 18 patients (11%) in the preparation stage were continuously abstinent through POD30. For those patients who were still smoking at POD30, the self-reported number of cigarettes smoked per day decreased slightly but significantly compared with that reported at the initial assessment (19.2 ± 9.4 at the POE to 15.4 ± 9.0 at POD30; $P < 0.001$, signed-rank test).

Stress, Nicotine Withdrawal, and Pain

At the time of the initial assessment in the POE, the NWS, the PSS, the NSS, and the NPS were all significantly greater in smokers compared with nonsmokers ($P <$ 0.001 for all comparisons). Each of these variables was found to decrease significantly ($P < 0.001$ for all comparisons) from the time of the initial assessment (in the POE) to the preoperative assessment (in the hospital immediately before surgery) (fig. 1). For the PSS and the NWS, the magnitude of the change from POE to immediately before surgery was dependent on smoking status (time–smoking status interaction, $P = 0.032$ and $P <$

Table 4. Tobacco Use Behavior on Day of Surgery through 30-Day Follow-up among Those Smoking at Enrollment (N = 141)

Characteristic	Monitored Anesthesia Care (n = 39)			Outpatient (n = 45)			Inpatient (n = 57)		
	Mean ± SD	Median	Range	Mean ± SD	Median	Range	Mean ± SD	Median	Range
Hours since last cigarette at preoperative assessment	5.2 ± 8.0	1.3	0.3, 36.4	4.3 ± 7.0	1.3	0.3, 39.7	13.1 ± 42.3	1.5	0.4, 309.1
< 1, No. (%)		12 (31)			13 (29)			17 (30)	
1–1.9		13 (33)			17 (38)			14 (25)	
2–7.9		4 (10)			4 (9)			5 (9)	
8–23.9		8 (21)			10 (22)			14 (25)	
≥ 24		2 (5)			1 (2)			6 (11)	
Expired carbon monoxide concentration at preoperative assessment	15.6 ± 11.4	13.5	1, 62	18.4 ± 14.6	15	1, 88	16.3 ± 11.1	14.5	1, 42
Days to first tobacco use after hospital discharge, No. (%)									
Used while hospitalized		0 (0)			0 (0)			3 (5)	
0		29 (74)			29 (64)			28 (49)	
1		6 (15)			8 (18)			3 (5)	
2 or 3		2 (5)			1 (2)			4 (7)	
4–7		0 (0)			3 (7)			3 (5)	
8–28		1 (3)			0 (0)			1 (2)	
No reported use at POD30 assessment		1 (3)			2 (4)			12 (21)	
Missing/incomplete data		0 (0)			2 (4)			3 (5)	
Current abstinence at POD30, No. (%)*		5 (13)			5 (11)			16 (28)	
Continuous abstinence through POD30, No. (%)*		1 (3)			2 (4)			12 (21)	
Change in cigarettes per day from baseline†									
All subjects	−7.0 ± 11.2	−3	−40, 8	−4.0 ± 9.0	−1	−34, 20	−8.7 ± 10.8	−5	−40, 5
Those smoking at POD30	−4.1 ± 8.2	−2	−37, 8	−3.0 ± 8.7	0	−34, 20	−4.3 ± 7.1	−2	−31, 5
Used nicotine patches, spray, gum, or medication while hospitalized, No. (%)									
All subjects		2 (5)			0 (0)			17 (30)	
Abstinent at POD30		1 (20)			0 (0)			6 (38)	
Continuous abstinence at POD30		0 (0)			0 (0)			5 (42)	
Have used nicotine patches, spray, gum, or medication to stop smoking since hospital discharge, No. (%)*									
All subjects		7 (20)			1 (2)			14 (26)	
POD30 abstinence		2 (40)			0 (0)			8 (50)	
Continuously abstinent subjects		0 (0)			0 (0)			6 (50)	
Interested in participating in a program to stop smoking, No. (%)‡		16 (53)			26 (68)			26 (70)	

* Three patients in the monitored anesthesia care group, two patients in the outpatient group, and four patients in the inpatient group could not be contacted for the assessment at postoperative day 30 (POD30). In addition, one patient in the monitored anesthesia care group who had smoked since hospital discharge died on POD23. All these subjects were assumed to be smoking at the POD30 assessment.

† Change in cigarettes per day from baseline is not available for the 10 patients who could not be reached at POD30 and is missing for 1 additional monitored anesthesia care patient. ‡ Interest in a program to stop smoking is reported for the 105 patients (30 monitored anesthesia care, 38 outpatient, and 37 inpatient) who were able to be reached at POD30 and reported smoking.

0.001, respectively), with smokers experiencing more of a decline than nonsmokers (fig. 1).

From data collected during the immediate perioperative period (defined as the time from preoperative [*i.e.*, immediately before surgery] to POD8 assessments), a consistent pattern was observed for the PSS (fig. 2), the NSS (fig. 3), and the NWS (fig. 4). For each variable, significant main effects were detected for time, smoking status, and anesthesia category ($P \leq 0.008$ for all factors). In general, the average values of these variables (1) decreased over time, (2) were higher for smokers compared with nonsmokers, and (3) were higher for patients undergoing inpatient procedures compared with outpatient procedures. These main effects were also detected in the analysis of the NPS (fig. 5). The supplemental analyses performed for the binary endpoints of any pain (NPS > 0) and any stress (NSS > 0) yielded similar results.

For the NSS and the NWS, there was no evidence to suggest that these differences between smokers and nonsmokers changed over time. However, for the PSS and the NPS, there was some evidence for such differences. For the PSS, the three-way interaction effect for smoking status, time, and anesthesia category was statistically

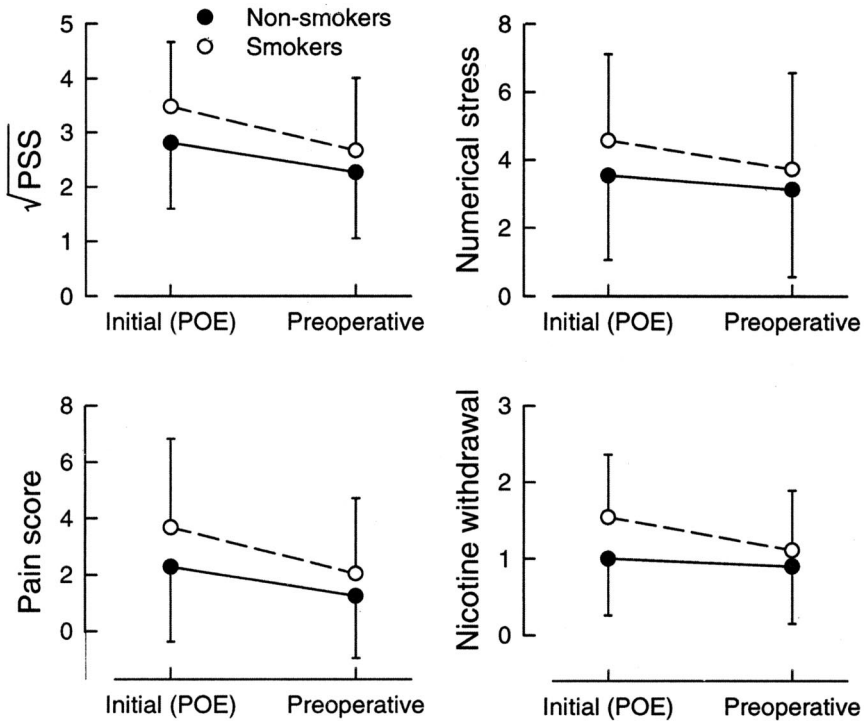

Fig. 1. Changes in the transformed (square root) Perceived Stress Score (PSS), numerical stress score, nicotine withdrawal score, and numerical pain score from the time of initial assessment in the preoperative evaluation clinic (Initial [POE]) to the preoperative assessment in the hospital immediately before surgery (Preoperative) for nonsmokers (n = 150) and smokers (n = 141). Values are presented as mean ± SD.

significant ($P = 0.003$), suggesting that for at least some anesthesia group(s), changes in perceived stress over the perioperative period differed between smokers and nonsmokers. From subsequent analyses performed separately for each anesthesia category, MAC was the only anesthesia category in which a significant two-way interaction between time and smoking status was detected ($P = 0.002$), with smokers observed to have less of a decrease in perceived stress immediately after surgery compared with nonsmokers. The NPS was higher for smokers compared with nonsmokers, was higher with increased anesthesia intensity, and was highest at POD1, followed by a decrease thereafter (fig. 5). The three-way interaction effect among smoking status, time, and anesthesia category was also found to be statistically significant ($P = 0.036$), indicating that for some anesthesia group(s), changes in pain during the perioperative period differed for smokers and nonsmokers. The MAC group was again the only anesthesia group in which a significant interaction between time and smoking status was found ($P = 0.016$), with smokers but not nonsmokers observed to have increased pain on POD2. In all of these cases, similar results were obtained when the analyses were repeated using only data collected while subjects were in the smoke-free hospital environment and when age, which differed significantly between groups, was included as a covariate.

There were 19 smokers who used nicotine replacement products or other smoking cessation medication in the hospital during the perioperative period; all but 2 of them were in the inpatient group. Four inpatients and 2 patients receiving MAC used nicotine patches throughout their hospitalization, 12 inpatients initiated nicotine patch use postoperatively while in the hospital (at a median of 2 days postoperatively), and 1 inpatient used bupropion. The analyses comparing smokers and nonsmokers with respect to PSS, NWS, NSS, and NPS using data collected while subjects were in the hospital environment were repeated with data collected after any subject reported using nicotine replacement therapy or

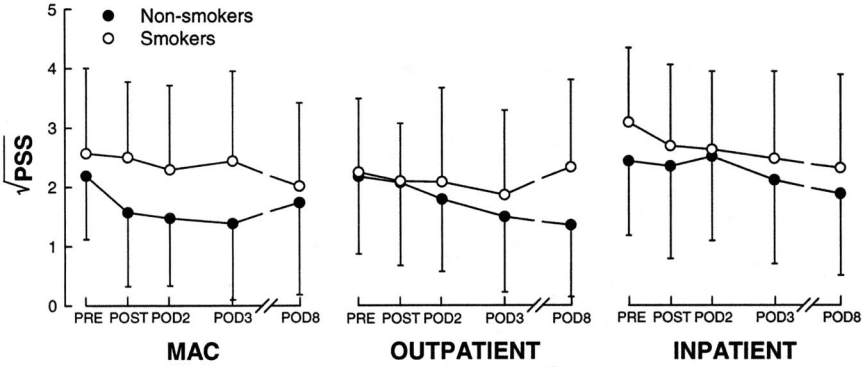

Fig. 2. Transformed (square root) Perceived Stress Scale (PSS) scores at the preoperative assessment in the hospital immediately before surgery (PRE), the first postoperative assessment (day of surgery, POST), the day after surgery (POD2), the following day (POD3), and 1 week after surgery (POD8). Scores for patients undergoing outpatient monitored anesthesia care (MAC), outpatient surgery requiring general or major regional anesthesia (OUTPATIENT), or inpatient procedures (INPATIENT) are shown separately. Values are presented as mean ± SD.

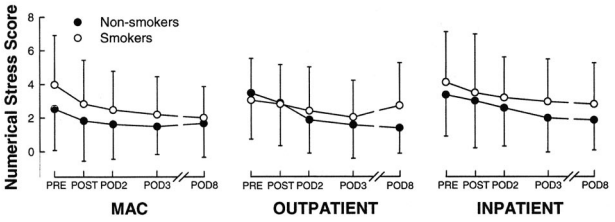

Fig. 3. Numerical stress scores at the preoperative assessment in the hospital immediately before surgery (PRE), the first postoperative assessment (day of surgery, POST), the day after surgery (POD2), the following day (POD3), and 1 week after surgery (POD8). Scores for patients undergoing outpatient monitored anesthesia care (MAC), outpatient surgery requiring general or major regional anesthesia (OUTPATIENT), or inpatient procedures (INPATIENT) are shown separately. Values are presented as mean ± SD.

bupropion was excluded. The findings from these analyses were similar to those obtained without these data excluded, suggesting that the use of such medications was not responsible for the pattern of results.

Supplemental analyses of smokers were performed using only data obtained while they were in the smoke-free hospital environment to determine whether results depended on smoking history or nicotine dependence (as assessed by the FTND). In these patients, the number of cigarettes smoked per day preoperatively was not found to be significantly associated with PSS, NWS, NPS, or NSS. For the PSS, there was evidence suggesting that values were higher for smokers with an FTND of 6 or greater compared with those with an FTND score of 5 or less ($P = 0.021$ for the main effect of FTND group). However, there was no evidence to suggest that the difference between FTND groups changed during the course of the perioperative period ($P = 0.977$ for the two-way interaction between FTND and time). For NWS, there was evidence of a two-way interaction between FTND and anesthesia category. From analyses performed separately for each anesthesia category, it was found that for the inpatients, NWS was higher for smokers with an FTND score of 6 or greater compared with those with an FTND score of 5 or less 5 ($P = 0.042$ for the main effect of FTND group). Again, there was no evidence to suggest that the difference between FTND groups changed during the course of the perioperative period ($P = 0.255$ for the two-way interaction between FTND and time).

To further investigate whether smokers with higher levels of nicotine dependence experienced nicotine withdrawal in the smoke-free hospital environment, an analysis was performed separately for the NWS craving item (fig. 6). Higher craving scores were found for smokers with FTND scores of 6 or greater compared with those with FTND scores of 5 or less ($P = 0.012$ for the main effect of FTND group), but no evidence was found to suggest that the difference between FTND groups changed during the course of the perioperative period ($P = 0.731$ for the two-way interaction between FTND and time).

Attribution of Stress

On POD 30, all subjects were asked to quantify the amount of perceived stress attributed to various sources (physical limitations, physical pain, medical costs, change of appearance, and risk of dying). In addition, smokers were asked to quantify the amount of perceived stress attributed to their efforts to quit smoking or remain smoke-free (fig. 7). Compared with nonsmokers, smokers were found to report significantly more stress attributed to physical pain ($P = 0.006$, rank sum test) and cost of medical care ($P = 0.014$). Among smokers, the amount of stress attributed to quitting smoking or remaining smoke-free did not differ significantly from that attributed to physical pain ($P = 0.520$, signed-rank test) or physical limitations ($P = 0.099$) and was greater than that attributed to medical costs ($P = 0.006$), change of appearance ($P < 0.001$), or fear of dying ($P < 0.001$).

Discussion

Stress and Nicotine Withdrawal

There is extensive literature on the relation between cigarette smoking and perceived stress.[3] Although smoking a cigarette reduces measures of stress in most studies, this response may represent self-medication for incipient nicotine withdrawal symptoms rather than a truly effective response to external stressors. In this way,

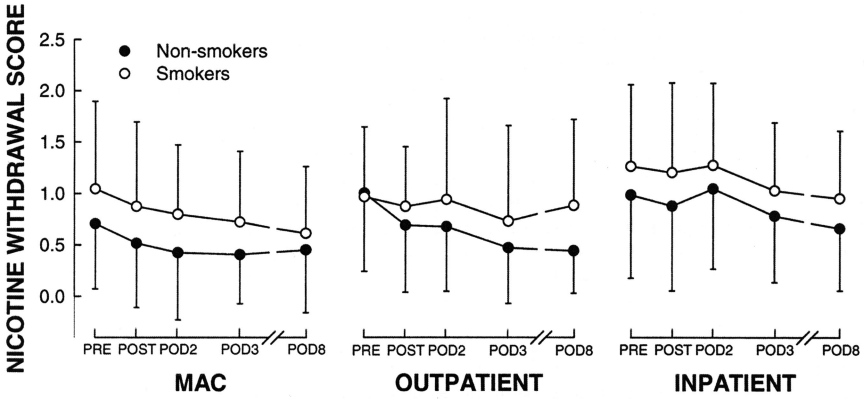

Fig. 4. Nicotine withdrawal scores at the preoperative assessment in the hospital immediately before surgery (PRE), the first postoperative assessment (day of surgery, POST), the day after surgery (POD2), the following day (POD3), and 1 week after surgery (POD8). Scores for patients undergoing outpatient monitored anesthesia care (MAC), outpatient surgery requiring general or major regional anesthesia (OUTPATIENT), or inpatient procedures (INPATIENT) are shown separately. To permit comparisons between smokers and nonsmokers, the item that assesses craving was not included in the score. Values are presented as mean ± SD.

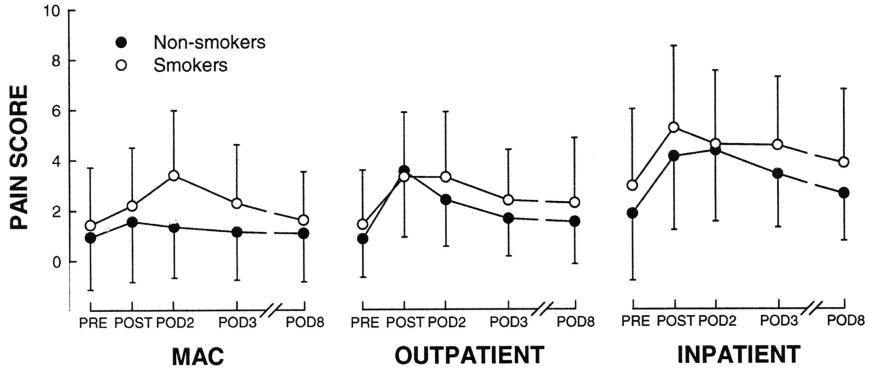

Fig. 5. Numerical pain scores at the preoperative assessment in the hospital immediately before surgery (PRE), the first postoperative assessment (day of surgery, POST), the day after surgery (POD2), the following day (POD3), and 1 week after surgery (POD8). Scores for patients undergoing outpatient monitored anesthesia care (MAC), outpatient surgery requiring general or major regional anesthesia (OUTPATIENT), or inpatient procedures (INPATIENT) are shown separately. Values are presented as mean ± SD.

smoking itself may directly contribute to stress,[3] and patients who quit smoking report decreases in perceived stress.[26] Our results are consistent with previous reports of general population-based samples in that PSS scores are increased in smokers compared with nonsmokers,[18] although the magnitude of the difference in the current study is greater than that previously reported. This finding is also consistent with a previous report that smoking was a risk factor for preoperative state anxiety.[27] Of interest, this difference was not reflected in responses to the Life Experiences Survey, designed to assess the occurrence of specific life change events. This suggests that smokers and nonsmokers had similar preoperative exposure to major life events or other major stressors, which would not explain the differences in perceived stress.

The general decrease in overall PSS scores in all patients during the immediate perioperative period might be expected as patients overcome the challenges posed by surgery. However, we found little evidence that changes in stress during this period differed between smokers and nonsmokers, with the exception of patients receiving MAC, in whom the PSS (but not the NSS) did not decrease as quickly after surgery in smokers compared with nonsmokers. In additional analyses, we considered three potential factors that could have modified any stress arising from changes in perioperative smoking behavior. First, many smokers quickly resumed smoking after surgery (especially outpatients), which may have helped to alleviate stress. However, similar results were observed if analysis was restricted to abstinent smokers only. Second, some patients (especially inpatients) used some form of nicotine replacement therapy, which may have alleviated stress. However, exclusion of these patients from analysis when they started using nicotine replacement therapy did not change the pattern of results. Finally, some patients were relatively light smokers, and this may have obscured any effects in more dependent smokers. However, although highly dependent smokers (FTND score $\geq$ 6) reported higher stress, severity of nicotine dependence was not a significant factor determining changes in stress. Therefore, our findings do not support the hypothesis that abstinence from cigarette smoking consistently contributes to psychological stress in the perioperative period. This finding suggests that perioperative factors other than smoking-related behavior seem to be more important determinants of changes in perceived stress around the time of surgery.

In particular, we found no evidence that symptoms of nicotine withdrawal contributed to perceived stress in the perioperative period. Indeed, we found little evidence for significant exacerbations of nicotine withdrawal symptoms in our patients, which again may reflect the fact that the duration of forced abstinence was relatively brief for many subjects or the fact that some subjects used nicotine replacement therapy. However, this finding held even when data from highly dependent, abstinent smokers were analyzed. Although highly dependent smokers (FTND score $\geq$ 6 preoperatively) reported higher withdrawal scores and higher craving, their craving actually decreased over the postoperative period (fig. 6). This result may be consistent with some previous suggestions that withdrawal symptoms may be

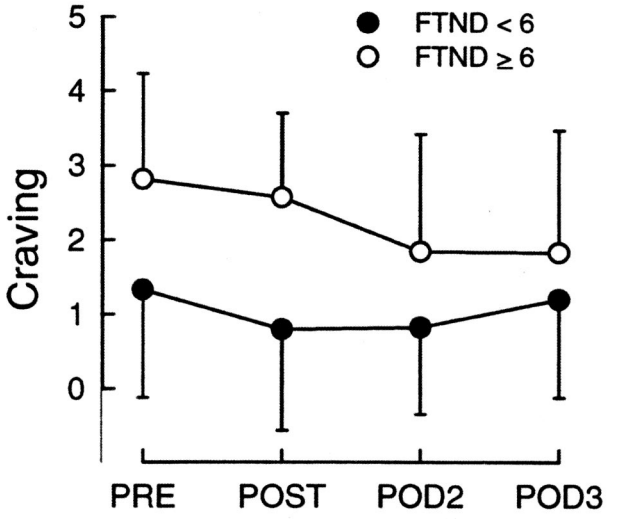

Fig. 6. Scores for the desire-to-smoke item (craving) of the nicotine withdrawal questionnaire for inpatient smokers. Values for patients with a Fagerström Test for Nicotine Dependence (FTND) score of 5 or less and 6 or greater are presented separately. Values are presented as mean ± SD.

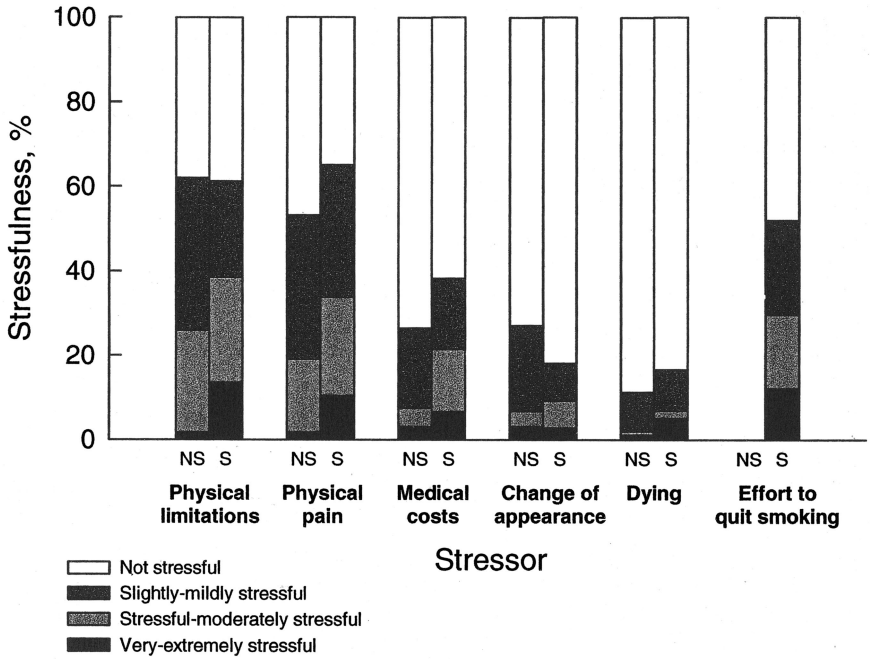

Fig. 7. Attribution of stress in nonsmokers (NS) and smokers (S) to various factors in the perioperative period, assessed on postoperative day 30. Subjects rated six sources of stress on a seven-point scale as not stressful, slightly stressful, mildly stressful, stressful, moderately stressful, very stressful, or extremely stressful. For purposes of presentation, the above categories were combined into four as shown in the figure. Values are presented as the percentage of responses falling within a given category.

mitigated under stressful situations that demand forced abstinence, such as military training or prisons.[28–30] Abstinence effects are accentuated in the smoker's natural environment, perhaps because smoking-related cues elicit conditional withdrawal[31]; in the absence of such cues, withdrawal symptoms may be lessened.

The decrease in the PSS from the time of initial assessment in the preoperative clinic to the immediate preoperative assessment in all groups (fig. 1) was unexpected. Although the PSS is well validated in the general population,[18] to our knowledge, it has not been previously applied specifically to the study of stress in the perioperative period, such that no studies are available for direct comparison. We chose to use the PSS because although stress and anxiety may be constructs that lie on the same continuum, measures such as the State Trait Anxiety Inventory, used in many previous studies of perioperative emotional states, are designed to assess anxiety, and not stress.[19] We had also noted this decrease in the PSS in pilot work performed to plan the current study and took two specific steps based on this experience. First, multiple family members are often present at the immediate preoperative assessment, and it is possible that their presence would reduce reported stress. For this reason, in the current study, private interviews were conducted for all assessments. Second, the PSS queries for specific responses to life events. Because the immediate preoperative assessment was usually performed in the morning and under unusual circumstances (*i.e.*, preparing for surgery), this setting alone may have affected responses. For this reason, we devised a simple NSS to provide a subjective rating of overall stress that did not depend on eliciting specific situational responses. Despite these measures, the overall pattern of changes in the PSS and the NSS were similar. In addition, we found similar results for two other measures that did not specifically measure stress, the NWS and the NPS. Therefore, this pattern does not seem to be specific to perceived stress, suggesting that it is not a feature peculiar to this specific assessment. We cannot explain this finding, which seems counterintuitive, other than to speculate that the focus on the impending event of surgery may actually improve states measured by these instruments. For example, the anticipation of imminent surgery that may relieve pain or have other benefit may reduce stress. Also, previous studies suggest that social support moderates stress responses,[32,33] and such support provided by increased attention from family members and others may have ameliorated stress. Interestingly, by the time of POD30, these measures had largely returned to the values measured at the initial assessment (table 5). This argues for their internal validity and suggests that some aspect of the surgical experience itself affects these parameters.

We measured pain to determine whether it would contribute to hypothesized differences in changes in perceived stress in the two groups caused by surgery. We confirmed previous observations that smokers report increased pain compared with nonsmokers,[34,35] as shown by significant differences at the initial assessment. These differences were maintained throughout the perioperative period. There was little evidence that changes in reported pain caused by surgery differed between smokers and nonsmokers, with the exception of patients receiving MAC. However, because exact matching of surgical procedure and thus the painful stimulus was not performed between groups and because perioperative analgesia was not standardized between the groups, this

Table 5. Perceived Stress Score, Numerical Stress Score, and Numerical Pain Score at Initial Assessment and 30 Days after Surgery

	Monitored Anesthesia Care				Outpatient				Inpatient			
	Nonsmokers (n = 48)		Smokers (n = 39)		Nonsmokers (n = 49)		Smokers (n = 45)		Nonsmokers (n = 53)		Smokers (n = 57)	
	Initial	POD30	Initial	POD30	Initial	POD30	Initial	POD30	Initial	POD30	Initial	POD30
PSS score	2.2 ± 1.1	2.4 ± 1.4	2.8 ± 1.4	2.9 ± 1.3	2.1 ± 1.2	2.3 ± 1.3	2.2 ± 1.2	2.8 ± 1.3*	2.5 ± 1.2	2.4 ± 1.2	3.1 ± 1.2	2.9 ± 1.4
Stress score	2.1 ± 2.4	2.6 ± 2.3	4.2 ± 3.0	3.7 ± 2.3	3.3 ± 2.7	2.4 ± 2.0	3.0 ± 2.5	3.1 ± 2.4	3.4 ± 2.5	2.8 ± 2.2	4.1 ± 3.0	3.3 ± 2.5
Pain score	1.0 ± 2.1	1.2 ± 2.2	1.5 ± 2.3	2.3 ± 3.1	0.8 ± 1.5	1.1 ± 1.6	1.5 ± 2.2	1.5 ± 2.3	1.9 ± 2.7	1.9 ± 1.8	3.0 ± 3.1	3.4 ± 2.5

Values are presented as mean ± SD.

* $P = 0.002$ compared with initial assessment within condition, paired t test.

POD30 = postoperative day 30; PSS = Perceived Stress Scale, expressed on a square root scale.

cannot be interpreted as showing that smokers do not experience greater surgical pain than nonsmokers.[36–38] Nicotinic receptors modulate pain, but the effects of nicotine provided by cigarette smoking on pain perception in humans are complex and not well understood.[39,40]

Even though changes in perceived stress did not differ during the perioperative period between smokers and nonsmokers, smokers reported that the effort specifically to quit or maintain abstinence was a source of stress equal to other important potential stressors such as pain or physical limitation. This was observed even though most patients were abstinent for only a brief period. Perioperative physicians routinely address patient concerns regarding issues such as pain; perhaps they should also routinely address patient concerns regarding smoking abstinence.

Smoking Behavior

Before discussing perioperative smoking behavior, two methodologic concerns should be mentioned. First, other than measurements of carbon monoxide in the preoperative period, we relied on patient self-reporting of smoking behavior because many of these patients were not available to return for biochemical validation. Although the sensitivity and specificity of self-reporting is relatively high in nontherapeutic studies of adults,[41] it is possible that these would overestimate the biochemically validated rates. As is customary, we assumed that the 10 smokers (7%) who could not be contacted for the 30-day assessment were in fact smoking at this time. Second, several patients in each group declined to provide answers to some questions regarding smoking behavior in the initial assessment; it is not known how this may have affected the distribution of responses.

Hospitalized patients have received considerable attention as recipients of efforts to encourage cessation.[8] For hospitalized patients, it seems that the chances of quitting increase with the severity of disease or medical intervention. For example, Crouse and Hagaman[42] found that of smokers undergoing cardiac interventions, 55% of patients undergoing coronary artery bypass grafting, 25% of patients undergoing angioplasty, and 14% of patients undergoing only angiography were abstinent 1 yr after the intervention, a significant difference that persisted even after adjustment for severity of disease. Few data are available regarding the smoking behavior specifically of noncardiac surgical patients,[43–45] especially those undergoing outpatient procedures. However, our self-reported abstinence rates support the concept that patients undergoing more extensive interventions (in our study, those undergoing inpatient procedures) have a greater likelihood of quitting. The rate of 30-day continuous abstinence (21%) in smokers undergoing inpatient procedures is also within the range of previous reports of surgical inpatients after discharge.[43,45]

There are no previous reports of the smoking behavior of a general population of surgical patients. Their baseline smoking behavior preoperatively was in many respects typical of a general population of smokers regarding the level of consumption, their levels of dependence, and the desire of most to quit and having made multiple previous attempts to do so. We ascertained the future intention of these smokers using a modification of the staging procedure according to the transtheoretical model.[46] This model has been used to explain how patients change behaviors such as smoking and has some predictive value for successful quitting.[11] Because all surgical patients undergo some period of forced abstinence, we adapted the stages of change to this setting by modifying the questions to query for the intent to maintain abstinence postoperatively or to initiate a cessation attempt postoperatively. Therefore, comparisons with previous studies using this construct should be made with caution. However, with this proviso, it does seem that interest in quitting in the perioperative period is high, with approximately 75% of stating an intention to quit permanently within 6 months of surgery. In a general population, approximately 60% of smokers plan to quit within 6 months.[47] Direct comparisons should be made with caution, given the possibility that smokers interested in quitting may have been more likely to accept enrollment in the study. It also seems that this method of staging has predictive value, because those patients who intended to maintain postoperative abstinence were more than 10 times as likely to do so compared with patients who did not express this intention. The role of

this construct in guiding interventions, which is controversial,[48,49] remains to be determined in the surgical population.

Our current medical practice seems to be ineffectual in recommending postoperative abstinence; only a minority of smokers could recall anyone advising them to quit preoperatively, and the majority smoked within 2 h of admission.[50] This exposes these patients to the potential adverse effects of substances such as nicotine and carbon monoxide on intraoperative and postoperative outcomes, effects which may include cardiovascular, respiratory, and wound-related complications. Although almost every smoker maintained abstinence while in the facility, most quickly resumed smoking after discharge.

Although only a few patients undergoing outpatient procedures used nicotine replacement therapy in the perioperative period, its use was more common in inpatients, with the rate exceeding that reported in previous studies of general hospital patients (5–7%).[51,52] There is reluctance among some surgeons to encourage nicotine replacement therapy in the postoperative period because of concerns regarding its effects on wound healing and the cardiovascular system.[53–55] Further studies are necessary to define the possible contribution of nicotine replacement therapy in the management of these patients. Although our study was not designed to evaluate its efficacy, the fact that the rate of 30-day continuous abstinence was approximately three times higher in patients who used postoperative nicotine replacement therapy at least provides a preliminary suggestion that, as in other settings, it could be efficacious in promoting quitting.

Hospital-based smoking interventions for inpatients, including those undergoing surgery, can be efficacious in helping smokers to quit,[8] including interventions directed specifically toward surgical inpatients.[44,45,56] This information regarding perioperative smoking behavior, and the apparent lack of contribution of abstinence to perioperative stress, may be useful in designing strategies to help surgical patients to quit. For example, it seems that routine nicotine replacement therapy may not be required to manage nicotine withdrawal symptoms. Special attention should be paid to those patients undergoing outpatient procedures, who make up the majority of the general surgical population in the United States and who have not been previously targeted for interventions.

Summary

Although perceived stress was greater in smokers than nonsmokers throughout the time surrounding surgery, there was little effect of smoking status on perioperative changes in stress accompanying the surgical experience. There was also no evidence that nicotine withdrawal consistently contributes to perceived stress in surgical patients. These findings suggest that the perioperative period may represent an excellent opportunity for smoking cessation interventions, an opportunity that is currently not being systematically exploited, especially in patients undergoing outpatient surgery.

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