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Smoking in Chronic Rhinosinusitis: A Predictor of Poor Long-Term Outcome After Endoscopic Sinus Surgery

Russell D. Briggs, MD; Steven T. Wright, MD; Stephanie Cordes, MD; Karen H. Calhoun, MD

Objective: **This study was designed to determine whether smoking patients have poorer outcomes after endoscopic sinus surgery (ESS) based on a reliable validated rhinosinusitis-specific quality-of-life outcomes test.** ***Study Design:*** **Retrospective chart and computed tomography (CT) review with telephone and letter questionnaire.** ***Methods:*** **Charts of 230 adult patients undergoing ESS for chronic rhinosinusitis between January 1995 and December 1998 were reviewed. Each participating patient completed a detailed questionnaire, including the Sino-Nasal Outcome Test-16 (SNOT-16), at an average of 52 months after surgery. Preoperative CT scans were reviewed and the findings used to stage the patients' conditions. Multivariate analysis was used to assess these data.** ***Results:*** **Eighty-two patients completed the questionnaire, with 26 who smoked at the time of surgery and continued to smoke at the time of answering the questionnaire (Smokers). Average SNOT-16 score in Smokers was 27.5, versus 18.2 in those who did not smoke at the time of surgery (Non-Smokers). There was a statistically significant correlation between elevated SNOT-16 scores and smoking ($P < .001$) and antibiotic use within the past year ($P < .001$). There was an association between high SNOT-16 scores and both prior smoking and passive smoke exposure that did not reach statistical significance ($P = .055$ and $P = .267$, respectively). CT staging scores and prior ESS were not statistically correlated with SNOT-16 scores.** ***Conclusions:*** **Smoking is associated with statistically worse outcomes after ESS based on average SNOT-16 scores. Although no investigator has proved that the effects of smoking on sinonasal health are reversible, we counsel smoking patients considering ESS about the desirability of smoking cessation (for this and many health reasons), and the possibility of a poorer postsurgery outcome should they continue smoking.**
Keywords: **Chronic rhinosinusitis, Sino-Nasal Outcome Test, SNOT-16, endoscopic sinus surgery.**
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INTRODUCTION

Chronic rhinosinusitis is a prevalent chronic disorder accounting for numerous patient visits to physicians. More than 30 million people are afflicted with this disease and spend millions of dollars on treatment each year.[1] Missed work and loss of productivity push the costs associated with rhinosinusitis even higher, and this is likely to worsen as the prevalence and incidence of rhinosinusitis is increasing.[2]

Endoscopic sinus surgery (ESS) has been advocated for those patients whose symptoms related to chronic sinus disease do not respond to medical management. Overall success rates with ESS have been very good. Senior *et al*.[3] reported long-term follow-up of 72 patients with chronic rhinosinusitis treated with ESS, with 98.4% of patients reporting symptom improvement after surgery.

This study also revealed, however, that smoking at the time of ESS worsened long-term outcome. There was a trend toward having more smokers in the revision surgery group (27%) than in the non-revision surgery group (10%).[3] Even more remarkable is that 100% of smoking patients with "severe" disease (stages 3 or 4 using Kennedy's computed tomography [CT] staging system) required a revision operation for persistent symptoms.[3]

Although it is known that chronic rhinosinusitis is a multifactorial disease process, anecdotal evidence from our patient population also suggests that smoking patients have higher rates of persistent rhinosinusitis-attributed symptoms after ESS. This study was undertaken to find out whether patients who smoked at the time of ESS had worse outcomes based on the Sino-Nasal Outcome Test-16 (SNOT-16). This outcome test tool, developed by Piccirillo,[4] is a shortened version of the 31-item Rhinosinusitis Outcome Measure and was chosen because it is a reliable, valid, and responsive instrument for measuring rhinosinusitis-specific health-related quality of life.[5]

METHODS AND MATERIALS

The charts of 230 adult patients who underwent ESS for chronic rhinosinusitis between January 1995 and December 1998 were reviewed. Patients with allergic fungal sinusitis or sinonasal malignancies were excluded from the study. A comprehensive telephone or letter questionnaire that included the SNOT-16 was provided to each patient. Each patient had a chance to review the

From the Department of Otolaryngology-Head and Neck Surgery, University of Texas Medical Branch, Galveston, Texas, U.S.A.

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Send Correspondence to Karen H. Calhoun, MD, Department of Otolaryngology, University of Texas Medical Branch, 301 University Boulevard, JSA 7.104, Galveston, Texas 77555-0521, U.S.A.

questionnaire before deciding whether to participate in the study. Magnitude scores for the SNOT-16 are based on a scale of 0 to 3, with worse symptoms corresponding to higher scores. Absolute scores are calculated by adding the total score for each of the 16 questions. Thus, the lowest score would be 0 and the highest 48.[6] A normal mean value based on control subjects is 10.50.[5] Given the retrospective nature of this study, preoperative SNOT-16 scores were not obtained.

A detailed smoking history was obtained from hospital records and patient recall that included quantification of prior, passive, and direct smoke exposure. Prior smoking was defined as having smoked at least 100 cigarettes in the past but not smoking at the time of the ESS. We recorded the number of years smoked and average number of cigarettes smoked per day. Passive smoke exposure was defined as any exposure to cigarette smoke directly within the household. This was quantified by summing the number of persons who smoked in the home and the number of cigarettes those people smoked per day. Smoking was defined as any smoking at the time of ESS. This was quantified as the number of cigarettes smoked at the time of ESS and the number of years of smoking. A detailed description of current smoking habits among these patients was also obtained.

We recorded postoperative sinusitis symptoms and treatment modalities, including antibiotic use, antihistamine use, nasal steroid use, and over-the-counter medication information. A detailed allergy history was obtained and information regarding asthma, inhaler usage, and steroid usage was collected. Prior endonasal surgery was documented and other social history, including educational level, was also determined.

The preoperative CT scan from each patient was reviewed and staged according to both the Lund-Mackay Radiological Staging System and the Harvard Computed Tomography Staging System.[7,8]

Statistical analysis was performed with SPSS version 9.0 statistical software (SPSS, Chicago, IL). The outcome variable was the absolute SNOT-16 score. Multivariate regression analysis was used to identify which variables correlated with elevated SNOT-16 scores. Associated variables were analyzed using the Spearman correlation coefficient for continuous variables and the Mann-Whitney U test for dichotomous variables. The level of significance for the analysis was set at $P \leq .05$.

RESULTS

Of the 230 patients identified who met inclusion criteria, 82 (36%) completed the telephone or letter questionnaire. Although not every respondent answered every question on the questionnaire, all completed the SNOT-16. There were 26 male respondents (32%) and 56 female (68%). The ages ranged from 18 to 77 years, with an average age of 47 years. The average time of follow-up from the most recent ESS was 52 months (range, 38–96 mo). A single endoscopic sinus surgery was the initial and only surgery required in 61 patients (74%), whereas 21 patients (26%) had prior endonasal surgery.

Of the 82 respondents, 26 (32%) reported that they smoked at the time of ESS (Smokers). Smokers averaged 20 cigarettes per day for 26 years, with a range of 10 to 40 cigarettes per day for 5 to 53 years. All patients smoking at the time of surgery continued to smoke at the time of the questionnaire. Sixteen Smokers also reported passive smoke exposure, with an average of 23 cigarettes for 27 years (range, 20–40 cigarettes for 10–40 yr).

Of the 56 patients (68%) who did not smoke at the time of surgery (Non-Smokers), 20 reported a prior smoking history (Ex-smoking Non-Smoker) averaging 26 cigarettes per day for 14 years (range, 10–56 cigarettes per day for 5–36 yr). None resumed smoking after ESS. Among the Ex-smoking Non-Smokers, 7 also had passive smoke exposure averaging 30 cigarettes per day for 17 years.

The Smokers' SNOT-16 score averaged 27.5, versus 18.2 for the Non-Smokers. Passive smoke exposure in Smokers increased the average SNOT-16 score to 30.6. The average SNOT-16 score in the Ex-smoking Non-Smokers was 22.1, and passive exposure in this group increased the average SNOT-16 score to 25.5.

Average preoperative CT scan scores in Smokers were 8.6 and 2.7 for the Lund-Mackay and Harvard systems, respectively. For Non-Smokers, the average scores were 9.4 and 2.3, respectively. This was not a statistically significant difference.

Multivariable stepwise regression analysis between SNOT-16 scores and each collected data field revealed correlations with only four variables: smoking, prior smoking, passive smoke exposure, and antibiotic usage within the previous 1 year. Further analysis utilizing the Mann-Whitney U test revealed a statistically significant correlation between high SNOT-16 scores and smoking ($P < .001$). Using Spearman's correlation coefficient, high SNOT-16 scores and antibiotic use in the previous year were also statistically associated ($P < .001$). Prior smoking and passive smoke exposure did not reach statistical significance on the Mann-Whitney U test ($P = .055$ and $P = .267$). Preoperative CT staging scores and prior endonasal surgery did not statistically correlate with SNOT-16 scores.

DISCUSSION

Chronic rhinosinusitis is a multifactorial disease. Determining the impact of individual etiologic factors on chronic rhinosinusitis has been difficult. Tobacco smoke exposure, however, is one factor that has convincingly been associated with the development of rhinosinusitis.[9]

The mechanism by which smoking predisposes to development of rhinosinusitis is not fully understood. As early as 1964, a report to the Surgeon General indicated that cigarette smoke may inhibit the transport time in ciliated cells of the upper aerodigestive tract.[10] Subsequently, numerous studies have documented increased mucociliary transport times in the nasal mucosa among smoking individuals.[11–13] Increased mucociliary transport times may lead to mucostasis with resultant inflammation of the sinuses leading to chronic rhinosinusitis. It is also possible that upregulation and production of proinflammatory cytokines such as interleukin-5, interleukin-8, and granulocyte-macrophage colony-stimulating factor from the tobacco smoke itself may be other factors responsible for inflammation of the sinuses in this setting.[14]

We undertook our study after noticing in our patient population that smoking patients seemed more likely to experience continued symptoms of chronic rhinosinusitis after ESS than did non-smoking patients. Senior *et al.*[3] also noted a surprisingly high number of revision endonasal operations in smoking patients because of persistent rhinosinusitis symptoms. We hypothesized that these post-ESS Smokers would have worse outcomes documented by higher SNOT-16 scores than Non-Smokers.

Among our patients, Smokers experienced continued post-ESS sinonasal symptoms even after an average of 52 months' follow-up. SNOT-16 scores were statistically higher in Smokers, even taking into account multiple other potential sources of sinonasal disease, such as allergic rhinitis, prior surgery, and Sampter's triad. Even with greater antibiotic usage within the previous year, SNOT-16 scores remained statistically significantly higher in Smokers. While antibiotic use within the previous year was strongly statistically correlated with higher SNOT-16 scores, this finding is not surprising, because patients with continuing rhinosinusitis-related symptoms are more likely to seek medical care and be prescribed antibiotics. The use of other medical therapies for rhinosinusitis (nasal steroids, decongestants) was not statistically correlated with higher SNOT-16 scores. It is not known, based on this study, whether the use of these medications improves outcomes and leads to potentially lower SNOT-16 scores after surgery. Further research to help answer this question is necessary.

There are several limitations to our study. We had no preoperative SNOT-16 scores, so could not assess the impact of surgery on nasal symptoms. Only 36% of potentially eligible patients answered the questionnaires. It is possible that patients with more severe symptoms may have been more interested in reporting their symptoms, which may have skewed our results. We asked patients to describe their smoking behavior at the time of surgery. While their recall of smoking versus not smoking was likely very accurate (nearly every ex-smoker can tell you the exact date they quit), their recall of number of cigarettes per day and recalled quantification of passive smoke exposure may not have been as accurate.

It is unknown whether tobacco smoke exposure and its effects on long-term sinusitis-related health outcomes is reversible. It has been shown that patients with prior smoking histories have similar mucociliary clearance times as non-smokers, a fact that may indicate reversibility to smoke-induced sinonasal mucosal alterations.[15] However, there was an association between prior smoking and higher SNOT-16 scores in this study. Although not reaching statistical significance, this association may indicate that it is possible that the underlying changes to the sinonasal mucosa from smoke may be refractory to both medical and surgical treatments. A prospective study evaluating changes in SNOT-16 score after ESS would be necessary to further evaluate this group of patients.

Although smoking was strongly correlated with higher SNOT-16 scores after ESS in this study, passive smoke exposure was not. A study by Dieterichs and Calhoun[15] revealed that heavy smoking (more than five packs per week) as compared to light smoking showed a trend toward statistically significant increases in mucociliary clearance times. Thus, it is possible that the degree, quantity, and method of tobacco smoke inhalation is important for alterations in the sinonasal mucosa that may lead to chronic rhinosinusitis.

Comorbid conditions such as asthma also were not associated with high SNOT-16 scores in this study. This is in agreement with other studies that have found that more than 90% of patients with asthma report improvement in symptoms after ESS.[3]

More severe CT sinus staging scores in this study did not correlate with higher SNOT-16 scores. This is in accordance with previous studies that have shown that patients with higher symptom severity based on CT scans have lower absolute levels of symptom severity after ESS.[16]

CONCLUSION

Smoking is associated with statistically higher postoperative SNOT-16 scores following ESS. Although no investigator has proved that the effects of smoking on sinonasal health are reversible, we counsel smoking patients considering ESS about the desirability of smoking cessation (for this and many health reasons), and the possibility of a poorer postsurgery outcome should they continue smoking.

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