The Association between Smoking and Plastic Surgery Outcomes in 40,465 Patients: An Analysis of the American College of Surgeons National Surgical Quality Improvement Program Data Sets

David Goltsman, M.B.B.S.
Naikhoba C. O. Munabi, M.D.
Jeffrey A. Ascherman, M.D.

New York, N.Y.; and Sydney, New South Wales, Australia

Background: Smoking is known to negatively impact postoperative wound healing and increase infection risk. However, few studies have investigated whether the negative effects of smoking are similar for different procedures. The authors examined the association between smoking and postoperative outcomes for a diverse range of plastic surgery procedures.
Methods: Using the American College of Surgeons National Surgical Quality Improvement Program data set, demographics and outcomes were examined for patients who underwent plastic surgery between 2007 and 2012. Multivariable logistic regression models assessed the relationship between smoking status and a range of postoperative outcomes, including medical and surgical complications and impaired wound healing. Patients were also evaluated for length of inpatient hospitalization while controlling for multiple demographic factors and type of procedure.
Results: Forty thousand four hundred sixty-five patients were identified from the data set, including patients who had undergone breast, upper and lower extremity, abdominal, and craniofacial procedures. Current smokers constituted 15.7 percent of the cohort. Smokers had a higher likelihood of surgical (OR, 1.37; $p < 0.0001$) and medical complications (OR, 1.24; $p = 0.0323$) and increased odds for wound complications (OR, 1.49; $p < 0.0001$) and wound dehiscence (OR, 1.84; $p < 0.0001$). Smokers were also found to have increased odds of these complications even when subgroup analysis was performed according to major Current Procedural Terminology categories. Smoking also increased the odds of superficial wound infections (OR, 1.40; $p < 0.0001$). No difference was observed in hospital length of stay between smokers and nonsmokers.
Conclusions: Smoking increases a multitude of postoperative complications after plastic surgery procedures. The effects of smoking on plastic surgery outcomes should be used to guide patients in preoperative smoking cessation and to evaluate protocols for managing patients who smoke. (*Plast. Reconstr. Surg.* 139: 503, 2017.)
CLINICAL QUESTION/LEVEL OF EVIDENCE: Risk, II.

Smoking remains a major public health issue in the United States, despite great reductions in its prevalence over recent decades. In 2012, the Centers for Disease Control and Prevention estimated that 42.1 million Americans (18.1 percent of adults) consumed tobacco regularly.[1] A large body of research has established smoking as a causal factor for a myriad of chronic illnesses[2,3];

From the Division of Plastic Surgery, Columbia University Medical Center, New York-Presbyterian Hospital; and the Department of Plastic Surgery, Prince of Wales Hospital.
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however, comparatively less research has examined whether smoking is associated with poorer surgical outcomes.[2–4] Studies to date have shown that complications of wound healing, such as necrosis and infection, are more common among current smokers and are thought to be attributable to the vasoconstriction and deoxygenation effects of nicotine and other tobacco-related chemicals.[5] In plastic surgery, numerous clinical studies have substantiated that current smokers are at higher risk of wound-related complications. However, the majority of this research has focused on patients undergoing breast procedures.[6–9] As is well known, the scope of plastic surgery includes procedures spanning all anatomical locations and tissue types. Therefore, the postoperative complications that are associated with smoking may not be observed equally in all plastic surgery procedures.

This study aims to identify whether smoking is associated with poor postoperative outcomes and wound-related complications in a diverse range of plastic surgery procedures, categorized according to Current Procedural Terminology codes. Using data from the 2007 to 2012 American College of Surgeons National Surgical Quality Improvement Program data sets, this is the largest known study examining the link between smoking and plastic surgery outcomes. In addition, to the best of our knowledge, this study represents the first to examine the effects of smoking on surgical outcomes for multiple specific categories of plastic surgery procedures.

Deidentified data were collected from the American College of Surgeons National Surgical Quality Improvement Program data sets. No institutional review board approval was necessary for this study.

METHODS

American College of Surgeons National Surgical Quality Improvement Program Data Sets

Data for the American College of Surgeons National Surgical Quality Improvement Program data sets were collected by trained research nurses employed at participating institutions. Each case (patient) in the data set comprises 240 Health Insurance Portability and Accountability Act–compliant variables, including demographics, preexisting comorbidities, intraoperative variables, and outcomes affecting morbidity and mortality. Patients were contacted by letter or telephone survey after discharge to cover outcomes for up to a 30-day follow-up period. A complete list of the variables collected as part of American College of Surgeons National Surgical Quality Improvement Program data sets is publicly available (http://www.acsnsqip.org/).

Data used in these analyses were extracted from all plastic surgery procedures identified in the 2007 to 2012 American College of Surgeons National Surgical Quality Improvement Program data sets. The 2012 Current Procedural Terminology codes were used to identify and categorize these procedures.

Dependent Variables

The dependent variables examined included a range of surgical complications: superficial wound infections, deep wound infections, organ space infections, wound dehiscence, pneumonia, reintubation, pulmonary embolism, urinary tract infection, postoperative bleeding/transfusion, graft or flap loss, deep venous thrombosis, sepsis, and return to operating room. Four composite outcome variables (i.e., major surgical complications, medical complications, wound complications, and wound infections) were created by combining certain specific outcomes. Major surgical complications included a deep wound infection, a graft/prosthetic loss, or an unplanned return to the operating room within the 30-day postoperative period. Medical complications included any of the following: pneumonia, pulmonary embolism, postoperative renal insufficiency (creatinine >2 mg/dl), urinary tract infection, stroke, myocardial infarction, symptomatic deep vein thrombosis, or sepsis. Wound complications consisted of superficial surgical-site infections, deep incisional wound infections, organ space infections, or wound dehiscence. Wound infections consisted of superficial surgical-site infections and deep incisional wound infections.

Independent Variable

The principal independent variable was the smoking status of the patient at the time of the procedure. This was categorized as a binary outcome: nonsmoker or smoker. The American College of Surgeons National Surgical Quality Improvement Program data set defines an active smoker as an individual who has smoked cigarettes at any point within the 12 months before surgery. The use of cigars, pipes, chewing tobacco, nicotine patches, or marijuana is not specified.

Statistical Analyses

All statistical analyses were carried out independently by two statisticians. The baseline variables used for the analysis were summarized using number and percentage in each group. Smoker and nonsmoker, and the general association between the categorical variables and group, were

analyzed using a chi-square test. The *p* values generated indicated the significance of a particular variable's outcome and the general association with smoking status.

Logistic regression models were used to examine associations between smoking and adverse outcomes. These analyses were adjusted for sex, race, age group, operation year, and Current Procedural Terminology code. The statistics of most interest in these analyses were the odds ratios (95 percent CI) and their *p* values. Logistic regression was also used with an interaction term for Current Procedural Terminology categories and the outcome variables to determine whether the effect of smoking was different for each of the Current Procedural Terminology categories. A *p* value was also generated from the regression to determine whether the interaction term contributed in explaining the variation in the outcome variable. The output produced included the odds ratios (with their 95 percent confidence interval) and the *p* value to test the significance of the interaction term.

A negative binomial model was used for the count endpoint hospital length of stay, with the analysis being adjusted for sex, race, age group, operation year, and Current Procedural Terminology code. The statistics of interest were the least-squares mean values (95 percent CI), the rate ratio (95 percent CI), the *p* value for the test that each rate ratio was different from 1, and the overall *p* value for the test that at least one of the rate ratios was different from 1.

RESULTS

Study Sample

The characteristics of the study sample, patient comorbidities, and details of the operations performed are shown in Table 1. During the study period, 40,465 plastic surgery procedures were performed and recorded in the American College of Surgeons National Surgical Quality Improvement Program data set. Of the patients recorded, 15.7 percent (n = 6341) were current smokers. Patients were mostly in the 50- to 59-year-old age group (26 percent) and the majority (68 percent) were Caucasian.

The most frequent procedure was breast reconstruction, which accounted for 25.0 percent (n = 10,044) of procedures; implant-based reconstructions were performed in 18 percent (n = 7356) and autologous reconstructions were performed in 7 percent (n = 2688) of the sample. Other frequently performed procedures were reduction mammaplasty [n = 6901 (17 percent)], abdominal procedures [n = 3231 (8 percent)], hand/upper extremity procedures [n = 4416 (11 percent)], lower extremity procedures [n = 990 (2 percent)], and craniofacial procedures [n = 1987 (5 percent)]. A complete list of demographic information and patient characteristics is shown in Table 1.

A significant proportion of the sample was obese [n = 13,334 (33 percent)] or had hypertension [n = 10,975 (27 percent)] or diabetes [n = 3199 (7.91 percent)] at the time of surgery. An open wound at the time of surgery was also relatively common [n = 3730 (9.22 percent)]. The majority of operations were clean [n = 34,214 (84.6 percent)]. The average length of hospital stay for the entire cohort was 2.12 ± 9.41 days.

Associations between Smoking and Adverse Surgical Outcomes

Tables 2 and 3 summarize the findings of logistic regressions examining associations between smoking status and a number of adverse surgical outcomes. Of all patients recorded, 3376 (8.34 percent) experienced postoperative complications. Medical complications occurred in 732 (1.81 percent), surgical complications occurred in 2016 (4.98 percent), and wound complications occurred in 1611 (3.98 percent) (Table 2).

The findings showed that smokers had a greater likelihood of surgical complications (OR, 1.37; 95 percent CI, 1.22 to 1.54; $p = 0.0001$) and medical complications (OR, 1.24; 95 percent CI, 1.02 to 1.5; $p = 0.0323$) than their nonsmoking counterparts. Smokers also had 1.49 times the risk of wound complications (95 percent CI, 1.31 to 1.70; $p < 0.0001$) and 1.84 times (95 percent CI, 1.41 to 2.41; $p < 0.001$) the likelihood of wound dehiscence compared with nonsmokers.

Associations between Adverse Surgical Outcomes and Current Procedural Terminology Major Categories for Smokers and Nonsmokers

Tables 4 and 5 summarize the findings of logistic regressions with an interaction term examining associations between adverse surgical outcomes among different body sites (as defined by the Current Procedural Terminology major categories) according to smoking status. The findings showed that surgical complications occurred with a greater likelihood for smokers in implant-based breast reconstruction (OR, 1.36; $p = 0.03$), hand/upper extremity (OR, 2.21; $p < 0.001$), lower extremity (OR, 2.14; $p < 0.001$), and craniofacial/head and neck (OR, 2.39; $p < 0.001$) procedures. Wound complications occurred with a greater likelihood in hand/upper extremity (OR, 2.79; $p < 0.001$), lower extremity

Table 1. Baseline Characteristics

Variable	Smoker (%)	Nonsmoker (%)	Overall (%)	*p**
Sex				
Male	2099 (33)	5570 (16)	7669 (19)	<0.0001
Female	4232 (67)	28,507 (84)	32,739 (81)	—
Not provided	10 (0)	47 (0)	57 (0)	—
Race				
African American	689 (11)	3300 (10)	3989 (10)	<0.0001
American Indian (or other)	19 (0)	97 (0)	116 (0)	—
Asian	64 (1)	632 (2)	696 (2)	—
Caucasian	4312 (68)	23,388 (69)	27,700 (68)	—
Hawaii Indian (or other)	15 (0)	67 (0)	82 (0)	—
Hispanic	35 (1)	170 (0)	205 (1)	—
Not provided	1207 (19)	6470 (19)	7677 (19)	—
Age group				
16–19 yr	83 (1)	472 (1)	555 (1)	<0.0001
20–29 yr	985 (16)	2911 (9)	3896 (10)	—
30–39 yr	1189 (19)	4671 (14)	5860 (14)	—
40–49 yr	1639 (26)	8140 (24)	9779 (24)	—
50–59 yr	1546 (24)	8861 (26)	10,407 (26)	—
60–69 yr	673 (11)	5877 (17)	6550 (16)	—
70–79 yr	194 (3)	2261 (7)	2455 (6)	—
80–89 yr	30 (0)	818 (2)	848 (2)	—
90–99 yr	2 (0)	113 (0)	115 (0)	—
Year of reconstruction				
2007	184 (3)	830 (2)	1014 (3)	<0.0001
2008	559 (9)	2338 (7)	2897 (7)	.
2009	896 (14)	3833 (11)	4729 (12)	—
2010	1046 (16)	5324 (16)	6370 (16)	—
2011	1620 (26)	9058 (27)	10,678 (26)	—
2012	2036 (32)	12,741 (37)	14,777 (37)	—
Type of procedure				
Breast reconstruction				
Autologous	294 (5)	2394 (7)	2688 (7)	<0.0001
Implant-based	993 (16)	6363 (19)	7356 (18)	—
Reduction mammaplasty	755 (12)	6146 (18)	6901 (17)	—
Other breast procedure	845 (13)	6941 (20)	7786 (19)	—
Abdominal procedure	357 (6)	2874 (8)	3231 (8)	—
Hand/upper extremity	1241 (20)	3175 (9)	4416 (11)	—
Lower extremity	241 (4)	749 (2)	990 (2)	—
Craniofacial/head and neck	529 (8)	1458 (4)	1987 (5)	—
Other	1086 (17)	4024 (12)	5110 (13)	—

*p values obtained from χ^2 analysis.

Table 2. Logistic Regression Analysis of Major Complication Categories between Smokers and Nonsmokers*

Parameter	No. (%)	OR (95% CI)	Overall *p*
Medical complication	732 (1.81)	1.24 (1.02–1.50)	0.0323
Surgical complication	2016 (4.98)	1.37 (1.22–1.54)	<0.0001
Wound complication	1611 (3.98)	1.49 (1.31–1.70)	<0.0001

*Analysis has been adjusted for sex, race, age group, operation year, and Current Procedural Terminology code.

Table 3. Logistic Regression Analysis of Wound Complications between Smokers and Nonsmokers*

Parameter	No. (%)	OR (95% CI)	Overall *p*
Wound dehiscence	315 (0.78)	1.84 (1.41–2.41)	<0.0001
Wound infection occurrences	1200 (2.97)	1.40 (1.40–1.63)	<0.0001

*Analysis has been adjusted for sex, race, age group, operation year, and Current Procedural Terminology code.

(OR, 2.69; $p < 0.001$), and craniofacial/head and neck (OR, 2.56; $p = 0.0027$) procedures. Medical complications occurred with a greater likelihood in lower extremity (OR, 2.84; $p < 0.001$) procedures.

Specific issues of dehiscence and wound infections were analyzed separately, yielding distinct information. Wound dehiscence occurred with a greater likelihood in reduction mammaplasty (OR, 2.16; $p = 0.01$) and lower extremity (OR, 2.35; $p < 0.02$) procedures. Wound infections occurred with a greater likelihood in hand/upper extremity (OR, 3.23; $p < 0.001$), lower extremity (OR, 2.33; $p < 0.01$), and craniofacial/head and neck (OR, 2.26; $p = 0.03$) procedures.

Smoking and Length of Hospital Stay

The findings from the negative binomial models (Table 6) showed that the average length of hospital

Table 4. Logistic Regression Showing the Effect of Smoking on Outcomes of Plastic Surgery Procedures According to Current Procedural Terminology Categorization

	Surgical Complications			Wound Complications			Medical Complications		
CPT Categorization	**OR**	**95% CI**	***p***	**OR**	**95% CI**	***p***	**OR**	**95% CI**	***p***
Breast reconstruction									
Autologous	0.86	0.61–1.18	0.37	1.17	0.80–1.66	0.41	1.03	0.55–1.81	0.91
Implant based	1.36	1.02–1.79	0.03	1.35	0.95–1.88	0.09	0.45	0.14–1.11	0.13
Reduction mammaplasty	1.22	0.78–1.84	0.36	1.07	0.77–1.46	0.68	0.37	0.06–1.24	0.18
Other breast procedure	0.96	0.65–1.38	0.84	1.26	0.85–1.82	0.23	0.82	0.28–1.92	0.68
Abdominal procedure	0.88	0.52–1.39	0.60	0.97	0.64–1.41	0.87	1.14	0.65–1.87	0.63
Hand/upper extremity	2.21	1.39–3.42	<0.001	2.79	1.68–4.52	<0.001	1.55	0.57–3.61	0.35
Lower extremity	2.14	1.46–3.08	<0.001	2.69	1.68–4.18	<0.001	2.84	1.83–4.33	<0.001
Craniofacial/head and neck	2.39	1.50–3.72	<0.001	2.56	1.35–4.65	0.0027	0.71	0.17–2.03	0.57
Other	1.86	1.54–2.24	<0.001	1.65	1.28–2.10	<0.001	1.53	1.15–2.01	0.0031

CPT, Current Procedural Terminology.

Table 5. Logistic Regression Showing the Effect of Smoking on Wound Complications According to Current Procedural Terminology Categorization

	Dehiscence			Wound Infections		
CPT Categorization	**OR**	**95% CI**	***p***	**OR**	**95% CI**	***p***
Breast reconstruction						
Autologous	1.62	0.73–3.28	0.20	1.15	0.75–1.72	0.50
Implant based	1.52	0.68–3.06	0.27	1.13	0.69–1.75	0.61
Reduction mammaplasty	2.16	1.13–3.94	0.01	1.01	0.70–1.42	0.94
Other breast procedure	2.21	1.00–4.66	0.04	1.12	0.68–1.75	0.64
Abdominal procedure	1.01	0.38–2.26	0.97	0.91	0.57–1.39	0.68
Hand/upper extremity	3.25	0.67–13.2	0.11	3.23	1.87–5.43	<0.001
Lower extremity	2.35	1.07–4.81	0.02	2.33	1.23–4.18	<0.01
Craniofacial/head and neck	2.32	0.50–8.34	0.22	2.26	1.03–4.60	0.03
Other	1.59	0.86–2.76	0.11	1.55	1.14–2.06	<0.01

CPT, Current Procedural Terminology; SSI, surgical-site infection.

stay was 2.08 days (95 percent CI, 1.88 to 2.3) for smokers and 2.05 days (95 percent CI, 1.87 to 2.25) for nonsmokers. There was no significant difference found between these two averages ($p = 0.6255$).

DISCUSSION

This study investigated the association between smoking and surgical complications after a range of plastic surgery procedures using the American College of Surgeons National Surgical Quality Improvement Program data sets. The findings showed that smoking increases postoperative complications after plastic surgery procedures, and the specific complications impacted varies according to the type of procedure performed. Smoking, however, had no impact on hospital length of stay in this analysis. The role of smoking in outcomes of plastic surgery should be used to guide patients in preoperative smoking cessation and counsel patients on operative risk, and may help to design protocols to improve postoperative outcomes in patients who do smoke.

Multiple studies have examined the effect of smoking on postsurgical outcomes.[10–14] Recently, Schmid et al. examined the impact of smoking after 16 major cardiothoracic, orthopedic, and oncologic surgery procedures. Using the American College of Surgeons National Surgical Quality Improvement Program data set, they found that smokers were at increased risk of cardiothoracic, pulmonary, neurologic, inflammatory (sepsis), and wound complications, consistent with previous reports.[14] However, they also discovered that the risk profile of smoking varies depending on the type of procedure.[14] Therefore, a new and better understanding may be gleaned from determining the impact of smoking on procedures within different surgical subspecialties, particularly in plastic surgery, where multiple tissue types and anatomical locations are included in surgical procedures. To the best of our knowledge, the current study represents the first population-based evaluation of the impact of smoking on a wide range of procedures specific to and within the field of plastic surgery.

In the current study, we identified a cohort of 40,465 patients from the 2007 to 2012 American College of Surgeons National Surgical Quality Improvement Program data sets who had

Table 6. Negative Binomial Model of Length of Hospital Stay*

Variable	Length of Stay (days)		Rate Ratio (95% CI)	*p*
	Mean	95% CI		
Total hospital stay				
Smoker	2.08	1.88–2.3	1.01 (0.96–1.06)	0.6225
Nonsmoker	2.05	1.87–2.25	Reference	—

CPT, Current Procedural Terminology.
*Analysis has been adjusted for sex, race, age group, operation year, and Current Procedural Terminology code.

undergone a range of plastic surgery procedures, including but not limited to breast, abdominal wall, upper and lower extremity, and craniofacial procedures. Breast-based procedures constituted the majority of reported cases. Of all patients, 15.7 percent were smokers, which closely approximates the national rate of smoking reported by the Centers for Disease Control and Prevention (18.1 percent of U.S. adults).[1]

The analyses showed that smoking increased the odds of medical (OR, 1.24), surgical (OR, 1.37), and wound (OR, 1.49) complications after plastic surgery procedures. On further examination of wound complications, we also found that smoking increased the likelihood of wound dehiscence (OR, 1.84) and the occurrence of wound infections (OR, 1.40). Although the negative impact of smoking on wound complications may seem well known, at least anecdotally, these findings are of particular importance in plastic surgery procedures. For many patients undergoing plastic surgery, obtaining optimal wound closure and aesthetic outcomes are principal objectives of the procedure. Therefore, a wound complication resulting in an impaired aesthetic result may impact objective success of an operation and patient satisfaction more so after a plastic surgery procedure than procedures performed by other surgical specialties.

Smoking was found to impact surgical complications differently depending on the location and type of procedure performed. When analyzed according to categories formed based on Current Procedural Terminology codes, smoking increased the likelihood of surgical complications after implant-based breast reconstruction (OR, 1.36) and hand and upper extremity (OR, 2.21), lower extremity (OR, 2.14), and craniofacial/head and neck (OR, 2.39) procedures. Lower extremity procedures (OR, 2.84) were also associated with a higher incidence of medical complications in smokers. However, smokers who underwent hand and upper extremity (OR, 2.79), lower extremity (OR, 2.69), and craniofacial/head and neck (OR, 2.56) procedures all had a greater likelihood of overall wound-related complications. These findings suggest that smokers who undergo lower extremity procedures are overall more likely to experience a complicated postoperative course.

The wound complication category was further subdivided into dehiscence and wound infections. Smoking increased the risk of wound dehiscence after reduction mammaplasty (OR, 2.16) and lower extremity (OR, 2.35) procedures. The increased risk of wound dehiscence after these procedures in smokers may reflect the amount of tension required to close incisions and local tissue ischemia that can be seen in these specific operations. Smoking, however, also increased the risk of infections in both lower extremity (OR, 2.33) and hand/upper extremity (OR, 3.23) procedures in addition to craniofacial/head and neck (OR, 2.26) procedures. The predilection of smokers who undergo these procedures to develop wound infections may be related to ischemia, but also likely suggests a greater incidence of preoperative trauma or wound contamination. Understanding the indications for extremity and craniofacial surgery in the study cohort would further assist in explaining the increased risk of infection for smokers in these categories.

The results of our study are similar to findings by Chung et al., who investigated the rate of surgical-site infections after free flap reconstructions in 2899 patients in the American College of Surgeons National Surgical Quality Improvement Program database. They found that patients who developed surgical-site infections were more likely to be active smokers (18.2 percent) compared with those patients who did not develop complications (8.4 percent; $p < 0.001$).[15] Their study, however, along with other studies in the literature, only evaluated patients undergoing breast reconstruction.[15,16] Our study provides evidence that the association between smoking and increased surgical-site infection extends to other anatomical locations and procedure types.

In addition to evaluating postoperative complications, we also queried how smoking impacted hospital length of stay after plastic surgery procedures. Reducing the cost of health care is of paramount importance to medical institutions nationally, impacting protocols for health care delivery. On average, reports suggest that the average cost of hospitalization in the United States exceeds $2100 per day.[17] However, despite the increased odds of postoperative complications after plastic surgery procedures, the negative binomial models revealed that smoking was not

found to have an impact on hospital length of stay. This may be because many wound-related complications in plastic surgery can be managed conservatively in the office setting. The length of hospital stay is not the only potential cost associated with postsurgical complications. Postoperative complications may also result in increased costs related to home nursing care, dressing supplies, visits to wound care centers, and other expenses following hospital discharge. However, given the variables provided in the data set, length of stay was the only outcome related to cost that was readily quantifiable for this study. Despite the fact that no difference was observed in length of stay, further studies investigating other variables associated with the costs of hospitalization and postoperative surgical care may reveal an increased expense of performing surgery on smokers.

The merit of data set studies is that clinical questions can be addressed using a large sample size, reducing the influence of individual surgical variability and allowing for more rare events to achieve adequate power. The American College of Surgeons National Surgical Quality Improvement Program data set, however, is not without limitations. First, with regard to smoking, the data set categorizes current smokers as anyone who smoked within 1 year of surgery. Therefore, patients who ceased smoking within this timeframe were included in our active smoking cohort. As a result, the impact of smoking on postoperative outcomes in plastic surgery may be even more drastic than we have reported. That is, if we had been able to separate our patients into three cohorts (i.e., active smokers, nonsmokers who quit within the past year, and nonsmokers who quit more than 1 year ago or patients who never smoked), we would likely have found an even greater distinction in outcomes between smokers and long-term nonsmokers or never-smokers. Unfortunately, more detailed and time-specific data are not available in the American College of Surgeons National Surgical Quality Improvement Program database. The data set is also limited because it does not capture the quantity of cigarettes smoked or the overall duration of smoking for either active smokers or previous smokers. As a result, we were unable to investigate whether there is a dose- or time-dependent relationship between active smoking and postoperative complications. In addition, the impact of peripheral vascular disease in patients with a history of smoking could not be assessed, but provides another interesting area for future studies.

Previous studies have investigated whether there is an optimal length of time that should elapse for cessation of smoking before and after surgery to minimize the risk of complications. Knobloch et al., in a 2008 review, reported that 4 weeks of abstinence from smoking lowered postoperative complication rates.[18] However, the temporal relationship between those 4 weeks and the surgical date was not defined. It remains unknown whether smoking cessation 4 weeks before surgery or 2 weeks before up until 2 weeks after surgery (for a total of 4 weeks) affects complication rates equally. Further studies into the timing of smoking cessation in relationship to surgical outcomes would help augment the findings of this study and assist clinicians to provide more specific patient counseling regarding preoperative smoking cessation. In addition, with regard to the timing of smoking cessation, it would also be helpful to know how much patients who actively smoke before surgery benefit by stopping only postoperatively (such as a trauma patient who actively smokes, but then quits following his or her trauma and reconstructive surgery).

Another limitation to the American College of Surgeons National Surgical Quality Improvement Program data set is that smoking status is based on patient report or medical record documentation rather than nicotine levels. A study by Coon et al. found that patient reporting of smoking habits is not always reliable, with 4.1 percent of patients who reportedly quit smoking having positive urine nicotine tests. In addition, patients who stated that they had quit smoking were significantly more likely to be deceitful than patients who never smoked.[19] In addition, the American College of Surgeons National Surgical Quality Improvement Program data set did not record the use of other nicotine products such as patches or gums, which may be more commonly used in patients who quit smoking and are therefore categorized as nonsmokers. Unfortunately, urine nicotine level is not a variable included in the data set. Adding this variable to the data registry could provide for a more accurate assessment of smoking status in future analyses.

The use of the American College of Surgeons National Surgical Quality Improvement Program data set for this study is also limited by the fact that the data set was designed primarily for general surgery and vascular surgery procedures. Therefore, although plastic surgery procedures are recorded, some of the more common complications seen in plastic surgery, such as seroma and fat necrosis, are not included.

Although the database reports on bleeding requiring transfusion within a 72-hour period of surgery, there is no documentation of postoperative hematomas, which often do not require the use of blood products in management. In addition, no data are included regarding which patients received permanent implants, such as breast implants or bony hardware, which are known to impact wound healing and infection risk. The data set is also limited because complications are monitored for only up to 30 days postoperatively. Some complications in plastic surgery may present outside of that window, however, such as chronic pain, capsular contracture, and implant exposure.

One potential limitation to the methodology of our study relates to the use of Current Procedural Terminology codes. The most recent coding system was used to provide consistency for how patients were identified in the database and therefore included in the study. However, any changes in Current Procedural Terminology codes over the years studied may result in patients or their outcomes being inappropriately categorized. Given the large number of patients in this study, however, such small aberrations in categorization of data resulting from slight changes in Current Procedural Terminology codes over the years would likely minimally affect the results. In other words, this study likely has sufficient power to support and validate our findings despite this potential variability.

Despite these limitations, the findings in this study provide important insights into the association between smoking and plastic surgery outcomes. In the future, we hope to evaluate how other variables (e.g., oncologic status) combine with smoking to impact outcomes. Ultimately, we aim to determine risk profiles for smoking after specific plastic surgery procedures at the population level. We also hope that these analyses can be used as a tool to help educate patients who smoke on expected outcomes after plastic surgery procedures. Based on our results, clinicians may be able to more easily define, explain, and quantify the rate of postoperative complications associated with smoking. In addition, this comprehensive analysis of the American College of Surgeons National Surgical Quality Improvement Program data set raises the possibility that some patients should be more strongly discouraged from certain procedures, particularly elective surgery, if they continue to smoke, given the higher risk of complications in smokers undergoing those procedures.[20]

CONCLUSIONS

Smoking has a multitude of negative effects on outcomes following plastic surgery procedures. The findings of this large population-based analysis will further assist plastic surgeons in anticipating the extent of morbidity that may be seen in smokers postoperatively and how those risks vary depending on the operative procedure. With this knowledge, plastic surgeons may be able to design better patient care protocols with regard to smoking, and can more accurately counsel patients on the benefits of smoking cessation.

Jeffrey A. Ascherman, M.D.
161 Fort Washington Avenue, Suite 509
Columbia University Medical Center
New York, N.Y. 10032
jaa7@cumc.columbia.edu

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