Surg Endosc
DOI 10.1007/s00464-014-3581-z

The effect of smoking on bariatric surgical outcomes

Ivy N. Haskins · Richard Amdur · Khashayar Vaziri

Received: 3 March 2014 / Accepted: 20 April 2014

Abstract
Background Bariatric surgery is an effective long-term treatment for morbid obesity. Although smoking is known to increase postoperative complications, the independent effect of smoking on bariatric surgical outcomes is unclear. The purpose of this study was to investigate the effect of smoking on bariatric surgical outcomes using the National Surgical Quality Improvement Program (NSQIP).
Study design Bariatric patients from 2005 to 2010 were identified in NSQIP for all types of bariatric procedures except adjustable gastric banding. Pre-treatment variables' univariate associations with smoking were examined with chi-square and *t* tests. Association of smoking with outcomes, corrected for relevant covariates, was tested with logistic regression within laparoscopic and open treatment groups.
Results A total of 41,445 patients underwent bariatric surgery (35,696 laparoscopic; 5,749 open). After controlling for covariates, smoking significantly increased the risk of organ space infection, prolonged intubation, reintubation, pneumonia, sepsis, shock, and longer length of stay in all patients undergoing bariatric surgery. In the open bariatric surgery subgroup, smoking was associated with a significantly higher incidence of organ space infection, prolonged intubation, pneumonia, and length of stay. In the laparoscopic surgery subgroup, smokers had a significantly increased incidence of prolonged intubation, reintubation, sepsis, shock, and length of stay. Smoking did not significantly increase the risk of mortality for patients undergoing bariatric surgery.
Conclusions These data suggest that smoking is a modifiable preoperative risk factor that significantly increases the incidence of postoperative morbidity but not mortality in both laparoscopic and open bariatric surgery. Smoking cessation may minimize the risk of adverse outcomes. Future investigation is needed to identify the optimal length of preoperative smoking cessation.

Keywords Bariatric surgery · Smoking · Outcomes · Morbidity · NSQIP

The goal of bariatric surgery is to use restrictive and/or malabsorptive techniques to provide sustained long-term weight loss and to improve or eliminate weight-associated comorbidities. Although previous reports have shown that these procedures can be performed safely, the bariatric patient population carries an inherently higher risk of morbidity and mortality as opposed to their non-obese counterparts [1–4]. The independent effect of preoperative cigarette smoking on bariatric surgical outcomes remains unclear, and most reports are small and without standardization of data collection. Despite the paucity of data, many bariatric surgeons recommend smoking cessation prior to their planned bariatric procedure. As the population of obese individuals continues to increase in the USA and worldwide, the number of weight loss procedures performed annually continues to rise [1]. Therefore, it is important to determine the effect of smoking on outcomes in bariatric surgery. This study investigates the effect of smoking on bariatric surgical outcomes using the National Surgical Quality Improvement Program (NSQIP). NSQIP

Presented at the SAGES 2014 Annual Meeting, April 2–5, 2014, Salt Lake City, Utah.

I. N. Haskins (✉) · R. Amdur · K. Vaziri
Department of Surgery, The George Washington University, 2150 Pennsylvania Ave., NW, Suite 6B, Washington, DC 20037, USA
e-mail: ihaskins@gwu.edu

K. Vaziri
e-mail: kvaziri@mfa.gwu.edu

Published online: 06 June 2014

Table 1 NSQIP data definitions

Outcome investigated	Definition
1. Superficial infection	Infection occurs within 30 days after the operation and involves only skin or subcutaneous tissues of the incision
2. Deep wound infection	Infection occurs within 30 days after the operation and involves the deep soft tissues (i.e., fascial and muscle layers)
3. Organ space infection	Infection occurs within 30 days after the operation and involves any part of the anatomy (except for the skin) that was opened or manipulated during an operation
4. Dehiscence	Separation of the layers of a surgical wound with disruption of the fascia within 30 days after the operation
5. Pulmonary embolism	Lodging of a blood clot in a pulmonary artery with subsequent obstruction of the blood supply to the lung parenchyma diagnosed by a V-Q scan read as high probability or positive CT spiral examination, pulmonary arteriogram, or CT angiogram
6. Prolonged intubation	Total duration of ventilator-assisted respirations during postoperative period was greater than 48 h at any time during the 30 days after the operation
7. MI	Transmural acute myocardial infarction occurring during surgery or within 30 days after the operation as manifested by new Q waves on electrocardiogram
8. DVT	New blood clot or thrombus within the venous system, diagnosed by duplex, venogram, or CT scan, within 30 days after the operation
9. Return to OR	Any intervention of any kind that required the patient to return to the operating room within 30 days after the original operation
10. Pneumonia	The patient is diagnosed with pneumonia if they developed either of the two criteria below within 30 days after the operation and pneumonia was not present preoperatively 1. Rales or dullness to percussion on physical examination OR 2. Chest radiographic examination shows new or progressive infiltrate, consolidation, cavitation, or pleural effusion Combined with new onset or purulent sputum or change in sputum, organism isolated from blood culture, or isolation of pathogen from specimen obtained via transbronchial aspirate, bronchial brushing, or biopsy
11. Reintubation	Patient required placement of an endotracheal tube and mechanical or assisted ventilation because of the onset of respiratory or cardiac failure manifested by severe respiratory distress, hypoxia, hypercarbia, or respiratory acidosis within 30 days after the operation
12. Cardiac arrest requiring CPR	The absence of cardiac rhythm or presence of chaotic cardiac rhythm that results in loss of consciousness requiring the initiation of any component of basic and/or advanced cardiac life support with 30 days of the operation
13. Bleed requiring transfusion	Any transfusion of packed red blood cells or whole blood given from the time the patient leaves the operating room up to and including 72 h postoperatively
14. Sepsis	Patient has two of the clinical signs or symptoms of SIRS and either a positive blood culture or a site thought to be causative of the infection
15. Shock	Patient has the clinical signs and symptoms of SIRS or sepsis and documented organ and/or circulatory dysfunction
16. LOS	Length of hospital stay in total greater than 7 days
17. Mortality	Death within 30 days of primary surgical procedure

is the first nationally validated, outcome-based program to objectively measure quality of surgical care [5].

Methods

All bariatric surgery cases from 2005 to 2010, with the exception of adjustable gastric banding, were identified in the NSQIP database using Current Procedural Terminology (CPT) codes. The open bariatric surgery cases included in this study were coded as 43,846, 43,842, and 43,843. Similarly, the laparoscopic bariatric surgery cases included in this study were coded as 43,644, 43,645, and 43,775. NSQIP provides a binary variable coded "yes" for patients who smoked cigarettes within the year prior to surgery. Cigar, pipe, and chewing tobacco use are excluded from this definition. Smokers and non-smokers were expected to vary on a variety of pre-treatment characteristics. The primary analysis was a multivariate model for each outcome. Smoking was used as the predictor, and any covariates that were associated with both smoking and the outcome were controlled for in order to minimize the affect of potential confounding variables.

The association between smoking and bariatric surgical outcomes was analyzed for open and laparoscopic bariatric surgery, open and laparoscopic gastric bypass, and open and laparoscopic non-gastric bypass procedures. The definitions of the adverse outcomes investigated are listed in

Table 2 Effect of smoking on all bariatric surgery outcomes N = 41,445

Outcome	*P*	Odds ratio (95 % confidence interval)
Superficial infection	.16	1.15 (0.95–1.40)
Deep wound infection	.93	1.02 (0.62–1.68)
Organ space infection	.01	1.45 (1.08–1.94)
Dehiscence	.74	0.90 (0.48–1.70)
Pulmonary embolism	.24	0.63 (0.29–1.37)
Prolonged intubation	.001	1.82 (1.26–2.63)
MI	.18	3.97 (0.54–29.27)
DVT	.15	0.62 (0.34–1.19)
Return to OR	.09	1.16 (0.98–1.38)
Pneumonia	<.0001	1.90 (1.42–2.54)
Reintubation	.01	1.62 (1.12–2.34)
Cardiac arrest requiring CPR	.74	1.15 (0.51–2.57)
Bleed requiring transfusion	.19	1.27 (0.89–1.83)
Sepsis	.01	1.49 (1.11–2.00)
Shock	.01	1.78 (1.16–2.74)
LOS > 7 days	.003	1.37 (1.12–1.67)
Mortality	.33	0.71 (0.36–1.41)

Table 3 Effect of smoking on open bariatric surgery outcomes N = 5,749

Outcome	*P*	Odds ratio (95 % confidence interval)
Superficial infection	.22	1.26 (0.87–1.81)
Deep wound infection	.34	0.63 (0.25–1.60)
Organ space infection	.03	1.79 (1.07–3.00)
Dehiscence	.92	1.05 (0.47–2.35)
Pulmonary embolism	.16	0.24 (0.03–1.75)
Prolonged intubation	.01	2.14 (1.21–3.80)
MI	.97	N/A*
DVT	.24	0.24 (0.10–1.76)
Return to OR	.45	1.17 (0.78–1.77)
Pneumonia	<.0001	3.06 (1.95–4.80)
Reintubation	.27	1.44 (0.76–2.72)
Cardiac arrest requiring CPR	.83	0.85 (0.25–2.95)
Bleed requiring transfusion	.38	0.58 (0.18–1.92)
Sepsis	.20	1.45 (0.82–2.57)
Shock	.19	1.59 (0.79–3.19)
LOS > 7 days	.03	1.47 (1.04–2.08)
Mortality	.19	0.39 (0.94–1.65)

* N/A = Unable to calculate due to low event rate

Table 1. Stepwise logistic regression was used for all binary outcomes. Hospital length of stay (LOS) was recoded into a binary variable based on LOS greater than 7 days. The threshold for inclusion and exclusion from each model was $P < .20$. This conservative approach kept possible confounds in the model even if they were not strictly significant because they still might have effected the smoking–outcome relationship. For each logistic regression model, the odds ratio for smoking was examined, along with its 95 % confidence interval, after correcting for all covariates. All data analysis was done using SAS, version 9.2 (Cary, NC), and $P < 0.05$ was considered statistically significant.

Results

All bariatric procedures

There were 41,445 patients in the NSQIP database who underwent bariatric surgery from 2005 to 2010. In all bariatric procedures, smoking had a significant increase in organ space infection, prolonged intubation, pneumonia, reintubation, sepsis, shock, and length of hospital stay greater than 7 days when compared to non-smokers (Table 2). Preoperative smoking did not lead to an increased risk of 30-day mortality.

Table 4 Effect of smoking on open, gastric bypass operations N = 3,911

Outcome	*P*	Odds ratio (95 % confidence interval)
Superficial infection	.93	0.98 (0.64–1.50)
Deep wound infection	.36	0.62 (0.22–1.75)
Organ space infection	.19	1.52 (0.82–2.81)
Dehiscence	.99	1.00 (0.42–2.40)
Pulmonary embolism	.20	0.27 (0.04–2.04)
Prolonged intubation	.05	1.93 (1.00–3.72)
MI	.97	N/A*
DVT	.21	0.28 (0.04–2.07)
Return to OR	1.00	1.00 (0.61–1.63)
Pneumonia	.002	2.39 (1.39–4.12)
Reintubation	.57	1.22 (0.61–2.43)
Cardiac arrest requiring CPR	.47	0.58 (0.13–2.56)
Bleed requiring transfusion	.14	0.23 (0.30–1.66)
Sepsis	.85	1.07 (0.54–2.12)
Shock	.43	1.37 (0.63–3.02)
LOS > 7 days	.19	1.31 (0.88–1.94)

* N/A = Unable to calculate due to low event rate

Open bariatric procedures

A total of 5,749 patients underwent open bariatric procedures. Smoking had a significant increase in organ space

Table 5 Effect of smoking on open, non-gastric bypass operations N = 1,838

Outcome	*P*	Odds ratio (95 % confidence interval)
Superficial infection	.02	2.54 (1.18–5.48)
Deep wound infection	.40	0.41 (0.05–3.26)
Organ space infection	.04	2.71 (1.06–6.91)
Dehiscence	.77	0.71 (0.07–7.15)
Pulmonary embolism	.96	0.00 (0.00–999.99)
Prolonged intubation	.13	2.59 (0.76–8.82)
MI	.97	N/A*
DVT	.71	0.68 (0.08–5.55)
Return to OR	.10	1.89 (0.89–4.00)
Pneumonia	<.0001	5.92 (2.57–13.66)
Reintubation	.33	2.19 (0.45–10.63)
Cardiac arrest requiring CPR	.55	2.92 (0.16–33.70)
Bleed requiring transfusion	.55	1.71 (0.30–9.70)
Sepsis	.10	2.43 (0.85–6.91)
Shock	.56	1.61 (0.33–7.74)
LOS > 7 days	.09	1.81 (0.91–3.62)

* N/A = Unable to calculate due to low event rate

Table 6 Effect of smoking on laparoscopic bariatric surgery outcomes N = 35,696

Outcome	*P*	Odds ratio (95 % confidence interval)
Superficial infection	.31	1.13 (0.90–1.42)
Deep wound infection	.48	1.24 (0.69–2.24)
Organ space infection	.10	1.35 (0.94–1.92)
Dehiscence	.52	0.71 (0.25–2.00)
Pulmonary embolism	.60	0.79 (0.34–1.86)
Prolonged intubation	.05	1.63 (1.01–2.64)
MI	.32	2.77 (0.37–20.65)
DVT	.29	0.68 (0.33–1.40)
Return to OR	.15	1.15 (0.95–1.40)
Pneumonia	.14	1.35 (0.91–2.00)
Reintubation	.04	1.61 (1.02–2.54)
Cardiac arrest requiring CPR	.58	1.35 (0.47–3.91)
Bleed requiring transfusion	.07	1.43 (0.98–2.10)
Sepsis	.04	1.44 (1.02–2.03)
Shock	.02	1.96 (1.14–3.36)
LOS > 7 days	.05	1.29 (1.00–1.66)
Mortality	.75	0.88 (0.40–1.93)

infection, prolonged intubation, pneumonia, and length of hospital stay (Table 3). The open bariatric procedure group was further divided into open gastric bypass and open non-gastric bypass procedures. The effect of smoking on these subgroups is illustrated in Tables 4 and 5. A total of 3,911 patients underwent open gastric bypass. Smokers in this subgroup had a significant increase in prolonged intubation and pneumonia when compared to non-smokers (Table 4). A total of 1,838 patients underwent open non-gastric bypass procedures. Smokers in this subgroup had a significant increase in superficial surgical site infection, organ space infection, and pneumonia when compared to non-smokers undergoing similar procedures (Table 5). Smoking did not lead to an increased risk of mortality in open bariatric procedures.

Laparoscopic bariatric procedures

A total of 35,696 patients underwent laparoscopic bariatric procedures. Smoking had a significant increase in prolonged intubation, reintubation, sepsis, shock, and length of stay regardless of the type of laparoscopic procedure performed (Table 6). Subgroup analysis of laparoscopic gastric bypass and laparoscopic non-gastric bypass procedures is shown in Tables 7 and 8. A total of 33,181 patients underwent laparoscopic gastric bypass. Smoking significantly increased return to the operating room, pneumonia, sepsis, and shock compared to non-smokers (Table 7). A

Table 7 Effect of smoking on laparoscopic, gastric bypass operations N = 33,181

Outcome	*P*	Odds ratio (95 % confidence interval)
Superficial infection	.26	1.15 (0.91–1.45)
Deep wound infection	.96	1.02 (0.52–1.98)
Organ space infection	.13	1.34 (0.92–1.95)
Dehiscence	.56	0.74 (0.26–2.07)
Pulmonary embolism	.44	0.69 (0.27–1.75)
Prolonged intubation	.16	1.46 (0.87–2.45)
MI	.34	2.69 (0.36–20.11)
DVT	.35	0.69 (0.32–1.50)
Return to OR	.04	1.52 (1.02–2.27)
Pneumonia	<.0001	1.90 (1.42–2.54)
Reintubation	.18	1.41 (0.86–2.31)
Cardiac arrest requiring CPR	.95	0.96 (0.28–3.24)
Bleed requiring transfusion	.12	1.37 (0.92–2.05)
Sepsis	.04	1.46 (1.02–2.09)
Shock	.03	1.89 (1.06–3.36)
LOS > 7 days	.06	1.29 (0.99–1.67)

total of 2,515 patients underwent laparoscopic non-gastric bypass procedures. Smoking had a significant increase in deep wound infection, prolonged intubation, and reintubation (Table 8). Smoking did not lead to an increased risk of mortality in laparoscopic bariatric procedures.

Table 8 Effect of smoking on laparoscopic, non-gastric bypass operations N = 2,515

Outcome	*P*	Odds ratio (95 % confidence interval)
Superficial infection	.67	0.79 (0.27–2.30)
Deep wound infection	.02	7.07 (1.32–37.81)
Organ space infection	.66	1.28 (0.44–3.73)
Dehiscence	.18	1.52 (0.82–2.81)
Pulmonary embolism	.36	2.85 (0.30–27.04)
Prolonged intubation	.03	5.47 (1.22–24.57)
MI	.97	N/A*
DVT	.59	0.57 (0.07–4.37)
Return to OR	.50	1.27 (0.64–2.51)
Pneumonia	.96	N/A*
Reintubation	.009	5.59 (1.54–20.34)
Cardiac arrest requiring CPR	.50	2.38 (0.19–29.31)
Bleed requiring transfusion	.26	2.12 (0.58–7.69)
Sepsis	.74	1.24 (0.35–4.37)
Shock	.21	2.86 (0.56–14.72)
LOS > 7 days	.63	1.27 (0.49–3.31)

* N/A = Unable to calculate due to low event rate

Table 9 Significant effects of smoking on bariatric surgery

	Morbidity	
All bariatric surgery	Organ space infection	Sepsis
	Prolonged intubation	Shock
	Pneumonia	LOS > 7 days
	Reintubation	
Open bariatric surgery	Organ space infection	
	Prolonged intubation	
	Pneumonia	
	LOS > 7 days	
Laparoscopic bariatric surgery	Prolonged intubation	
	Reintubation	
	Sepsis	
	Shock	
	LOS > 7 days	

Significant effect of smoking

Table 9 summarizes the statistically significant increased adverse outcomes of smokers undergoing bariatric surgery when compared to non-smokers.

Discussion

The effects of smoking on surgical outcomes have been studied for almost 70 years with the first reports dating back to 1944 [6]. Since that time, more than 300 studies have been published that identify smoking as a risk factor for increased morbidity after surgery. However, the majority of these studies included smoking in multivariate analyses to determine risk factors associated with increased morbidity and mortality postoperatively. Most interestingly, in a systematic review by Theadom and Cropley in 2006, patients who continued to smoke before all types of surgery were at increased risk for superficial and deep wound infections, anastomotic leak (organ space infection), pneumonia, prolonged intubation, sepsis, myocardial infarction, and stroke [7]. Additionally, in 2006, Livingston et al. published the first study using NSQIP to identify risk factors associated with adverse surgical outcomes after bariatric surgery in the US veterans population. This study identified BMI $\geq$ 50, weight > 350 pounds, and smoking within the year prior to surgery as patient variables associated with increased morbidity and mortality [8]. This study was the first to use a standardized protocol for data collection, and it specifically identified patient risk factors that contribute to adverse surgical outcomes among US veterans, the system with the highest reported rate of morbid obesity in the USA [8]. However, this study did not identify the specific surgical outcomes impacted by preoperative smoking.

Our study reveals that smoking significantly increases pulmonary complications (prolonged intubation, reintubation, and pneumonia), organ space infection, and increased length of hospital stay in all types of bariatric surgery. Expectantly, pulmonary complications are the most common adverse outcome affected by smoking in all subgroups, while an increased incidence of pneumonia is found in all open bariatric surgery and laparoscopic gastric bypass only. The increased risk of pneumonia in the open surgery subgroup may be due to the operative approach which requires an upper midline incision. This upper midline incision has been shown to result in increased postoperative pain, which subsequently leads to a restrictive breathing pattern and poor pulmonary function [9].

Within the laparoscopic group, an increase in pneumonia was seen in the gastric bypass subgroup but not in the non-gastric bypass subgroup. This is likely a result of the relative size of the subgroups. The laparoscopic gastric bypass group contains 33,181 patients, while the non-gastric bypass group contains only 2,515 patients. When combined, the increase in the number of patients, along with the extremely low incidence of pneumonia in the non-gastric bypass group, likely dilutes the risk of pneumonia in the entire laparoscopic cohort.

Smoking also increased the incidence of organ space infection in all bariatric procedures and specifically in the open bariatric procedure subgroup. Organ space infection is defined as an infection of any part of the anatomy that was manipulated during the procedure except for the skin, muscle, and fascia as

these are identified separately by superficial and deep surgical site infections. Organ space infections include intraperitoneal abscesses, staple line leaks, and anastomotic leaks. The increased risk of organ space infection in smokers who have undergone open bariatric surgery is an important finding as anastomotic and staple line leaks are a major morbidity and a common causes of mortality after bariatric surgery [10, 11]. Interestingly, the subgroup analysis in open bariatric procedures shows an increase in organ space infection and superficial site infection in the non-gastric bypass cohort as opposed to the gastric bypass group suggesting that this outcome may not be a function of gastrointestinal anastomoses. An alternative explanation for the increased risk of organ space infection may be due to the difference in visualization and manipulation of the tissues intraoperatively. The laparoscopic approach provides better visualization throughout the procedure, likely resulting in less tissue manipulation, serosal damage, enterotomy creation, spillage, and tension. Additionally, laparoscopic inspection of staple lines allows for oversewing or reinforcement as needed which may not have been seen in the open procedures. These factors, in conjunction with the vascular effects of smoking, may lead to the increased risk of organ space infections in open bariatric surgery.

The exact mechanism by which cigarette smoking causes detrimental effects on surgical outcomes remains unknown. The increased perioperative morbidity associated with cigarette smoking is thought to be a combination of both its long-term health consequences and acute toxic effects [12]. The toxins in cigarette smoke cause detachment of endothelial cells from the lumen of blood vessels [13]. These endothelial cells are integral to forming a protective barrier against tissue swelling, platelet aggregation, angiogenesis, and prevention of vasospasm [14]. Additionally, nicotine, the major addictive agent in cigarettes, activates the sympathetic system and causes a surge of catecholamine release which in turn leads to decreased production of prostaglandins and increased platelet aggregation [15]. Finally, carbon monoxide binds to hemoglobin and decreases the oxygen-carrying capacity of blood [16]. The combined affects of nicotine and carbon monoxide lead to hypercoagulation and tissue hypoxia, which ultimately adversely affects and delays all aspects of wound healing [16].

In addition to altering wound healing, cigarette smoking also blunts the pulmonary immune response and predisposes patients to pneumonia and other respiratory complications. The toxins in cigarette smoke impair the ability of cilia to filter dust and remove mucus secretions from the lungs. This leads to increased airway inflammation, bronchial reactivity, and impaired alveolar macrophage function [17–19]. Impaired pulmonary function leads to poor postoperative pulmonary reserve and altered antimicrobial defense which can affect a patient's ability to successfully wean from the ventilator and avoid pulmonary complications.

Finally, smoking was associated with an increased length of hospital stay for all bariatric surgery regardless of the open or laparoscopic approach. This is may be a sequela of the increased risk of pulmonary complications associated with smoking. This increased length of stay leads to a substantial increase in healthcare costs. A recent study by Dimick et al. [20] revealed that pulmonary complications associated with perioperative smoking result in an average cost of $52,000 per surgical incident. In the global atmosphere of limiting healthcare costs while improving quality of care, smoking cessation may be a key element in preoperative risk reduction in the bariatric surgical population.

A limitation of our study involves the definition by which a patient is identified as a smoker in NSQIP. The NSQIP definition of smoking identifies patients who have smoked cigarettes only within the year prior to surgery. This definition does not allow for investigation into the effect of other sources of nicotine, such as nicotine patches and gum, on bariatric surgery outcomes. Additionally, this definition does not identify how much or how close to surgery the patient has smoked or whether the patient is a current smoker. Although smoking cessation may lead to decreased postoperative morbidity and mortality, the length of time required to see this beneficial effect is unknown and has been mostly investigated in thoracic surgery [20–24]. Future studies that investigate the effects of smoking on surgical outcomes should include all forms of nicotine and seek to identify the specific preoperative length of smoking cessation needed to mitigate adverse surgical outcomes.

Conclusions

Smoking significantly increases postoperative morbidity and length of stay in patients who undergo bariatric surgery when compared to non-smokers. Smoking significantly increases pulmonary complications in all bariatric procedures and organ space infections in open bariatric procedures. These data suggest that smoking cessation may minimize postoperative morbidity in bariatric surgery. Future investigation is needed to identify the optimal length of preoperative smoking cessation.

References

1. Finks J, Kole K, Yenumula P et al (2011) Predicting risks for serious complications with bariatric surgery: results from the Michigan bariatric surgery collaborative. Ann Surg 254(4):633–638
2. Encinosa W, Bernard D, Du D et al (2009) Recent improvements in bariatric surgery outcomes. Med Care 47:531–535

3. Birkmeyer N, Dimick J, Share D et al (2010) Hospital complication rates with bariatric surgery in Michigan. J Am Med Assoc 304:435–442
4. Flum D, Belle S, King W et al (2009) Perioperative safety in the longitudinal assessment of bariatric surgery. N Engl J Med 361:445–454
5. NSQIP History. ACS NSQIP Website. http://site.acsnsqip.org/program-specifics/nsqip-history/. Accessed June 11, 2013
6. Morton H (1944) Tobacco smoking and pulmonary complications after operation. Lancet 4:368–370
7. Theadom A, Cropley M (2006) Effects of preoperative smoking cessation on the incidence and risk of intraoperative and postoperative complications in adult smokers: a systematic review. Tobacco Control 15:352–358
8. Livingston E, Arterburn D, Schifftner T et al (2006) National surgical quality improvement program analysis of bariatric operations: modifiable risk factors contribute to bariatric surgical adverse outcomes. J Am Coll Surg 203:625–633
9. Masoomi H, Reavis K, Smith B et al (2013) Risk factors for acute respiratory failure in bariatric surgery: data from the nationwide inpatient sample, 2006–2008. Surg Obes Other Relat Dis 9(2):277–281
10. Masoomi H, Kim H, Reavis K et al (2011) Analysis of factors predictive of gastrointestinal tract leak in laparoscopic and open gastric bypass. Arch Surg 146(9):1048–1051
11. Froehling D, Daniels P, Mauck K, et al (2013) Incidence of venous thromboembolism after bariatric surgery: a population-based cohort study. J Metabolic Surg All Care. Retrieved September 16, 2013: http://link.springer.com.proxygw.wrlc.org/article/10.1007%2Fs11695-013-1073-1/fulltext.html
12. Khullar D, Maa J (2012) The impact of smoking on surgical outcomes. J Am Coll Surg 215(3):418–426
13. Krueger K, Rohrich R (2001) Clearing the smoke: the scientific rationale for tobacco abstention with plastic surgery. Plast Reconstr Surg 108:1063–1077
14. Townsend C (2012) Wound healing in Sabiston textbook of surgery: the biological basis of modern surgical practice, 19th ed. Saunders, Philadelphia, PA
15. Chang L, Buncke G, Slezak S et al (1996) Cigarette smoking, plastic surgery, and microsurgery. J Reconstr Microsurg 12(7):467–474
16. Riefkohl R, Wolfe J, Cox E et al (1986) Association between cutaneous occlusive vascular disease, cigarette smoking, and skin slough after rhytidectomy. Plast Reconstr Surg 77:592
17. Saetta M, Turato G, Baraldo S et al (2000) Goblet cell hyperplasia and epithelial inflammation in peripheral airways of smokers with both symptoms of chronic bronchitis and chronic airflow limitation. Am J Respir Crit Care Med 16(3):1016–1021
18. Garey K, Neuhauser N, Robbins R et al (2004) Markers of inflammation in exhaled breath condensate of young healthy smokers. Chest 125:415–420
19. Lensmar C, Elmberger G, Skold M et al (1998) Smoking alters the phenotype of macrophages in induced sputum. Respir Med 92(3):415–420
20. Dimick J, Chen S, Taheri P et al (2004) Hospital costs associated with surgical complications: a report from the private-sector national surgical quality improvement program. J Am Coll Surg 199(4):531–537
21. Mason DP, Subramanian S, Nowicki ER et al (2009) Impact of smoking cessation before resection of lung cancer: a society of thoracic surgeons general thoracic surgery database study. Ann Thorac Surg 88:362–371
22. Bluman LG, Mosca L, Newman N et al (1998) Preoperative smoking habits and postoperative pulmonary complications. Chest 113(4):883–889
23. Moller AM, Villebro N, Pederson T et al (2002) Effect of preoperative smoking intervention on postoperative complications: a randomised clinic trial. Lancet 359:114–117
24. Barrera R, Shi W, Thaler HT et al (2005) Smoking and timing of cessation: impact on pulmonary complications after thoracotomy. Chest 127(6):1977–1983