

REVIEW ARTICLE

Asthma, Surgery, and General Anesthesia: A Review

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Over 20 million Americans are affected with asthma. Many will require some type of surgical procedure during which their asthma management should be optimized. Preoperative assessment of asthma should include a specialized history and physical as well as pulmonary function testing. In many asthmatic patients, treatment with systemic corticosteroids and bronchodilators is indicated to prevent the inflammation and bronchoconstriction associated with endotracheal intubation. The use of corticosteroids has not been shown to adversely affect wound healing or increase the rate of infections postoperatively. Preoperative systemic corticosteroids may be used safely in the majority of patients to decrease asthma-related morbidity.

Keywords asthma, surgery, general anesthesia, preoperative evaluation, corticosteroids

INTRODUCTION

As of 2002, the CDC reported that asthma was estimated to affect 21.9 million adult Americans (1). For many of these patients, modern treatments for asthma such as inhaled corticosteroids have safely enabled them to participate in daily activities without disabling limitations (2). However, it is well known that asthma is not a curable disease. Airway hyperreactivity, an inextricable part of an asthmatic patient's lungs, can be triggered by a multitude of potential stimuli—many of which are not easily predicted by patients or physicians. Although physicians cannot remove patients from all stimuli of bronchospasm, they can prevent or decrease the frequency of asthma exacerbations occurring as a result of exposure to many known triggers of the disease. These may include allergic triggers such as cat dander, environmental changes such as cold air, exercise-induced triggers, and iatrogenic triggers such as surgery.

One of the most effective ways of managing asthma is prevention. Over the past decade, there has been increasing evidence to support the efficacy and safety of prophylactic treatment of asthma before surgery (3–5). Oral corticosteroids and bronchodilators before surgery decrease the incidence of pulmonary complications postoperatively and are well-tolerated with a low incidence of adverse effects (3–6).

ANESTHESIA AND BRONCHOSPASM

General anesthesia may trigger asthma exacerbations through several mechanisms. These include alteration of diaphragmatic function, impaired ability to cough, and decreased mucociliary function (7). Placement of the endotracheal tube itself is a potent airway irritant that may trigger bronchoconstriction in asthmatic patients (6). The above changes in lung function can lead to atelectasis, mucus plugging, and wheezing postoperatively. They may also lead to prolonged intubation, hypoxemia, and pneumonia. Patients

may not be able to verbalize symptoms from changes in their lung function secondary to sedation and lack of activity postoperatively. Older patients are at higher risk for perioperative respiratory complications such as aspiration, bronchospasm, and prolonged mechanical ventilation. (8–10). Therefore, a coordinated “team” approach is optimal for asthmatic patients who require surgery. All members who will be involved in the patient's care before, during, and after surgery should be aware of the patient's underlying lung disease. For example, the anesthesiologist may choose to avoid specific anesthetic agents that have previously been associated with bronchospasm (8, 11).

SPECIFIC ANESTHETIC AGENTS AND BRONCHOSPASM

Asthma exacerbations have been reported with certain intravenous and inhaled anesthetic agents. There have been case reports of allergic reactions and bronchospasm with thiopental and propofol infusion in patients (12). According to Nishiyama et al., the effect of propofol on the airway differs with the formulation of the drug used (13). Preservatives or stabilizing agents such as Cremaphor EL in thiopental formulations have the potential to produce anaphylactic reactions or allergic reactions (12). Despite these case reports, propofol is most commonly known to cause bronchodilation as a side effect (14). The majority of asthmatic patients have tolerated propofol, thiopental, and ketamine without an adverse reaction. Although no single neuromuscular blocking agent has been shown to be superior in reducing airway reactivity, D-tubocurarine, atracurium, and mivacurium have been associated with bronchospasm. This may be in part due to the fact that muscle relaxants have been shown to release histamine. This effect of muscle relaxants may be potentiated with increasing doses or rates of administration (12). Volatile anesthetic agents such as sevoflurane, isoflurane, and halothane have been reported to cause bronchodilation and therefore decrease airway resistance after endotracheal intubation (15).

Keeping the patient well-informed is another important component to reduce perioperative complications in patients with asthma. Patients should be educated on the need for preoperative evaluation and potential change in therapy before

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surgical procedures. They should be instructed to notify the surgeon of their condition as early as possible. Patients should also be instructed to plan for a preoperative assessment of their asthma by the managing physician, often an allergist or pulmonologist, one week before surgery.

PREOPERATIVE ASSESSMENT

Preoperatively, the majority of patients will need to be assessed by a physician. Currently, most internal medicine guidelines focus on a cardiac evaluation. A few include pulmonary function testing or objective assessment of respiratory symptoms as part of a routine preoperative history and physical (7). Many studies have suggested that asthmatics be assessed by their physician approximately one week before surgery to optimize treatment plans. Because preoperative treatment with oral steroids is not indicated in all asthmatics, a specialized history and physical and often spirometry is necessary before surgery (16, 17). Increased use of bronchodilators, recent exacerbations, or hospital visits are important risk factors for bronchospasm perioperatively. Some of the most useful clinical information to obtain during the history is listed in Table 1. Important historical elements include the number of times per week the patient requires a short-acting beta agonist, whether the patient has an upper respiratory tract infection or flare of chronic sinusitis that may have triggered symptoms, how often oral steroids have been used and for what duration, the last time the patient required oral steroids and the dose required, and whether the patient currently uses inhaled steroids or has used them in the past (17).

Several sources suggest that pulmonary function tests or spirometry before surgery is a useful component of the preoperative pulmonary assessment in patients with asthma and/or other chronic obstructive pulmonary diseases (17, 18). An objective assessment of lung function is especially important in patients who are poor historians or poor perceivers of their symptoms (7, 19). If the patient's symptoms are severe, surgery may need to be delayed until the precipitating factor is treated, such as a chronic sinus infection or community-acquired pneumonia (18). If there is concern for pneumonia, a chest radiograph should be obtained before surgery to document the pneumonia and the patient should be treated with antibiotics before surgery. Another potential trigger of asthma symptoms is gastroesophageal reflux disease (GERD). Approximately 77% of patients with asthma have GERD, which may or may not be symptomatic (20, 21). Control of GERD in adults and children often results in a significant improvement of asthma symptoms. Treatment of GERD may

TABLE 1.—Items to obtain during preoperative history.

Asthma control and current therapy
1. Increased use of inhaled short-acting beta agonists? Use per week?
2. Current or past use of inhaled corticosteroids?
3. Recent asthma exacerbation? Did this require ER or hospital visit?
4. Most recent course of oral corticosteroids?
Asthma history and complicating conditions or factors
1. Recent upper respiratory tract infection or sinus infection?
2. Recent pneumonia? Was this documented on chest radiograph?
3. History of intubation or ICU admission for asthma?
4. History of pulmonary complications with prior surgical procedures?
5. History of long-term corticosteroid use or corticosteroid-dependent asthma?

include lifestyle changes and medication such as an H₂ antagonist or a proton pump inhibitor (PPI) (22).

PREOPERATIVE THERAPY

The goals of preoperative therapy are to reverse inflammation and bronchospasm so as to reduce the likelihood of intraoperative or postoperative asthma flares. Corticosteroids such as prednisone have been shown to improve lung function within hours of administration (23, 24). General guidelines for preoperative pharmacotherapy are listed in Table 2. If the patient has no symptoms before surgery, does not require any asthma medications, and has not had any flare in asthma symptoms over the past year, then preoperative treatment with oral or inhaled steroids is not necessary. However, if the patient is on bronchodilators only and has no history of oral corticosteroid use then he or she should be treated with an inhaled corticosteroid such as beclomethasone 400 µg per day or equivalent dose one week before surgery. If the patient is already on inhaled steroids then he or she should be treated with prednisone 0.5 mg/kg for 5 days before surgery (17). If the patient is on oral steroids chronically, then the dose should be increased for 5 days before surgery. Patients who are already on inhaled steroids or oral steroids should also receive hydrocortisone 100 mg intravenously every 8 hours, to be started the morning before surgery and continued postoperatively until symptoms are stable (17). Intravenous steroids are recommended because the patient will not be able to take steroids orally before surgery. Intravenous hydrocortisone in stress doses may also be necessary to prevent Addisonian crisis (25). Patients at increased risk for adrenal insufficiency include those who have received greater than 20 mg of prednisone or equivalent dose of another glucocorticosteroid daily for a duration greater than 5 days (26). Asthmatic patients requiring emergency surgery should also receive 100 mg of intravenous hydrocortisone every 8 hours to be started before surgery and continued postoperatively until respiratory

TABLE 2.—Guidelines for preoperative pharmacotherapy.

Clinical characteristics of asthma	Corresponding preoperative pharmacologic therapy
<ul style="list-style-type: none"> • No asthma symptoms • Not on any asthma medications • No flares in asthma symptoms over past year • Spirometry does not show significant obstruction 	<ul style="list-style-type: none"> • No additional asthma therapy preoperatively
<ul style="list-style-type: none"> • On bronchodilators only • No history of oral corticosteroid use • Spirometry is not below baseline 	<ul style="list-style-type: none"> • Initiate therapy with inhaled corticosteroid, beclomethasone 400 µg per day or equivalent dose, one week before surgery • If spirometry is below baseline or patient is having flare of symptoms consider adding prednisone 0.5 mg/kg for 5 days before surgery
<ul style="list-style-type: none"> • Already on inhaled corticosteroid • Spirometry at or below baseline 	<ul style="list-style-type: none"> • Continue treatment with inhaled corticosteroid • Treat with prednisone 0.5 mg/kg for 5 days before surgery • Treat with hydrocortisone 100 mg IV every 8 hours the morning before surgery and postoperatively until stable
<ul style="list-style-type: none"> • Patient is already on oral steroids 	<ul style="list-style-type: none"> • Increase dose of oral steroids for 5 days before surgery • Treat with hydrocortisone 100 mg IV every 8 hours the morning before surgery and postoperatively until stable

symptoms are stable. The dose of intravenous hydrocortisone may need to be increased to 200 mg every 8 hours after surgery until symptoms have stabilized.

Treatment with inhaled bronchodilators has also been shown to increase lung function before surgery. The combination of systemic corticosteroids and inhaled bronchodilators has been shown to significantly decrease the incidence of wheezing postoperatively and increase lung function in a study by Silvanus et al. (6). Scalfaro et al. reported that in a study of children with asthma undergoing induction with sevoflurane before intubation, salbutamol alone before intubation prevented an increase in measured respiratory resistance (27). The reflex bronchoconstriction caused by intubation itself may, in part, be prevented by bronchodilators. Local anesthetics such as lidocaine, however, have not been shown to decrease the reflex bronchoconstriction associated with endotracheal intubation (28).

Several other factors may contribute to asthma exacerbations perioperatively. Care should be taken to prevent aspiration during intubation. If possible, patients should be placed with the head of the bed elevated to prevent aspiration-related pneumonia and resultant asthma exacerbations (29, 30). The patient may be treated with a PPI to decrease the incidence of an asthma exacerbation from gastroesophageal reflux (31). Patients undergoing surgery are at risk for GERD as they are often restricted to the supine position. Anxiety is also a known precipitant of asthma symptoms and should be treated perioperatively when indicated (18, 32). Incentive spirometry and deep breathing should also be encouraged to prevent atelectasis (33). Theophylline is relatively contraindicated in asthmatic patients undergoing surgery and, ideally, should be discontinued perioperatively. Theophylline has been shown to cause ventricular arrhythmias in patients receiving inhalational anesthetics, in particular, halothane. This drug has also been shown to antagonize the effects of neuromuscular blocking agents and benzodiazepines (34).

CORTICOSTEROIDS AND POSTOPERATIVE COMPLICATIONS IN PATIENTS WITH ASTHMA

Corticosteroid therapy as outlined in Table 2 has not been shown to cause an increase in complications postoperatively (5). In patients' status postthoracic surgery, low-dose corticosteroid therapy for adult respiratory distress syndrome (ARDS) did not increase the rate of wound infections or affect wound healing (35). In a study by Su et al., 172 patients with asthma undergoing a variety of surgical procedures were analyzed, retrospectively, for complications including postoperative infections, adrenal insufficiency, and asthma exacerbations (3). Preoperative steroids were administered to patients before 240 of the 249 procedures performed. The patients were either treated with prednisone orally, hydrocortisone intravenously, or both. None of the patients studied showed signs or symptoms of adrenal insufficiency. A total of 5.2% developed bronchospasm after surgery. Total infections occurred in 3.6%, wound infections in 1.6%, and delayed wound healing in 1.6%. The percentage of total infections and wound infections was no greater than that of surgical patients who did not receive corticosteroids. There was a statistically significant difference in the incidence of infections only in patients undergoing obstetrical procedures.

These patients had a slightly higher percentage of upper respiratory infections that did not result in asthma exacerbations. In a prospective randomized study of 66 patients undergoing surgery for esophageal cancer, half were given preoperative corticosteroids and all patients were followed for complications postoperatively. The patients who received prophylactic methylprednisolone before surgery had a decreased incidence of pulmonary failure. This group of patients did not exhibit delayed wound healing. They also did not have a higher incidence of infection in comparison to patients undergoing the same procedure who did not receive corticosteroids before surgery (36). Sauerland et al. conducted a review of patients who received a single dose of methylprednisolone preoperatively and found that there was no significant increase in the incidence of wound-related complications or gastrointestinal bleeding. In addition, the patients who received methylprednisolone did have a significant decrease in perioperative pulmonary complications (37).

Corticosteroids decrease allergic inflammation, in part, by blocking the transcription factors that lead to the production of inflammatory cytokines. Mitsuta et al. studied the lung parenchyma of 10 patients: 5 asthmatics and 5 controls without asthma undergoing lung resection for lung cancer (38). The patients with asthma were treated with oral and intravenous corticosteroids before surgery. The patients without asthma were not treated with corticosteroids. Lung tissue from non-asthmatic patients was sensitized with atopic serum, treated with or without dexamethasone, and then mite antigen was added. The tissue was analyzed with PCR, ELISA, and tryptase staining to compare levels of IL-5 and TNF-alpha mRNA as well as histamine, LTE4, and tryptase. Preoperative steroids completely suppressed IL-5 and TNF-alpha production at the mRNA level. The same results were obtained in sensitized lung tissue from non-asthmatic patients, comparing treatment with or without dexamethasone. Other studies have also shown that although steroids have a suppressive effect on adaptive immunity, they actually enhance many responses of innate immunity in the lung (39).

CONCLUSIONS

Although there is a general concern for the immunosuppressive effects of steroids increasing the rate of infection or preventing wound healing in asthmatic patients postoperatively, there is no definitive evidence suggesting that asthmatic patients treated preoperatively with steroids, as outlined in Table 2, are at increased risk for these complications. The asthmatic patient should undergo specialized evaluation before surgery to determine if bronchodilators, inhaled, oral, and intravenous steroids, or all four are indicated before surgery. Preoperative steroids and bronchodilators have been shown to decrease the rate of postoperative pulmonary complications in adult and pediatric patients with asthma by suppressing inflammatory cytokines that lead to airway hyperreactivity and by improving lung function before surgery. The routine use of preoperative steroids and bronchodilators in the carefully selected asthmatic patient will decrease morbidity in this patient population and allow them to undergo a variety of surgical procedures safely.

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