The Preoperative Management of Patients with Bronchial Asthma

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THE MANAGEMENT of the patient with bronchial asthma throughout the surgical period requires sound therapy based upon careful clinical and laboratory evaluation in order to reduce operative and postoperative complications. Pulmonary problems are a common cause of morbidity and mortality during major abdominal or thoracic surgery. In terms of frequency, 1.2 to 4 per cent of patients undergoing major surgical procedures are reported as having bronchial asthma.[1,2] Complications in patients with pulmonary disease have been documented; only 3 per cent of patients with normal preoperative pulmonary function will develop atelectasis or pneumonia, whereas 70 per cent of patients with chronic obstructive lung disease with altered pulmonary function will encounter such difficulties.[3] Shnider reported that 6.5 per cent of previously asymptomatic asthmatic patients develop bronchospasm during surgery.[1] Gold and Helrich found a 24 per cent incidence of operative and postoperative complications in an asthmatic population, as contrasted with 14 per cent in a control group.[4] In a limited study, cardiac arrest was more than 20 times as common in asthmatics as in similar controls.[2]

Several papers stress the reduction in operative and postoperative complications in patients with asthma who receive careful preoperative medical therapy.[1,5] Thus, it is clear that intensive preoperative management of such patients is a prerequisite to any significant surgical procedure. This chapter will deal with the factors we consider important in the preoperative approach, namely:

(1) Definition of the clinical disease
(2) Physiologic evaluation
(3) Risk factors—factors promoting bronchospasm or respiratory insufficiency
(4) Therapeutic considerations
(5) Preanesthetic and anesthetic techniques, hazards

It must be emphasized that each medical program must be individualized because of the variable responses which commonly occur in patients with asthma.

DEFINITION OF THE PATIENT TYPE

The distinction between a latent or asymptomatic patient and one with active disease is necessary in formulating a therapeutic program. Individuals with pure, intercurrent attacks of asthma should be recognized since emotional

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or surgical stress may precipitate gross bronchospasm. An adequate history and physical examination in conjunction with simple spirometric testing are usually adequate for definition. Simple pulmonary mechanics, i.e., measurement of vital capacity (VC), maximum expiratory flow rate (MEFR), first second forced expiratory volume ($FEV_{1.0}$), and maximum voluntary ventilation (MVV), should be performed before and after bronchodilator agents to determine the extent and degree of reversible bronchospasm. Latent bronchoconstriction which may not be detectable clinically may also be established.

Patients with continuous, active bronchial asthma require more intensive preoperative evaluation to clarify reversible precipitating factors, the extent of disease, and the degree of physiologic impairment. The clinical manifestations of wheezing, cough, sputum production, and even dyspnea may be similar to those of patients who have chronic asthmatic bronchitis, with the possible historical qualification of seasonal variations. However, the purely allergic group will usually not show evidence of infection, and their mucoid sputum will reveal eosinophils, macrophages, bronchial epithelial cells and a few polymorphonuclear neutrophil cells, in contrast to the purulent component of asthmatic bronchitic sputum, with its greater percentage of polymorphonuclear neutrophils and the presence of bacteria. Such groups may overlap nosologically, but clinically the approach will be different. Furthermore, a patient with chronic bronchitis or pulmonary emphysema may have a significant "bronchospastic" or allergic component, as defined by the allergic history, sputum or blood eosinophilia, and response to bronchodilators. The full range of these disorders must be appreciated and defined for appropriate therapy during the surgical period. When emergency surgery is necessary, a full therapeutic program must be instituted in the absence of an extensive preoperative evaluation. The therapeutic considerations relative to these descriptions will be discussed subsequently.

Preoperative Evaluation

A wide spectrum of asthmatic patients may be present, from the minimally symptomatic to those with chronically persistent disease. Only the most life-threatening surgical situations should make it necessary to intervene during an acute asthmatic episode. Although general anesthesia may produce bronchial relaxation under these circumstances, the postoperative period may be stormy because precipitating causes were poorly controlled initially. Generally, we will accept the premise that full medical care will be provided prior to surgery. The history and clinical evaluation should determine potentially precipitating factors, the severity of past attacks and, particularly, the dependency on and response to steroids and bronchodilators. If dyspnea is a constant or noteworthy complaint, other remediable causes such as anemia, cardiac disease or hyperthyroidism may be underlying. Contributory maxillary sinusitis, otitis media or hiatus hernia (potential aspiration) should be recognized as possible triggering mechanisms which may activate asthma during the stress period. Coexisting medical conditions which may adversely influence ventilation and contribute to operative complications include cardiac disease, neuromuscular disorders, restrictive problems of obesity, kyphoscoliosis, spondylitis, and coexisting

pulmonary disorders such as pleuritis, bronchiectasis, bronchitis, emphysema and pulmonary fibrosis. The recognition of persistent respiratory symptoms such as cough, sputum production, dyspnea and reduced exercise tolerance may suggest these last-named disorders.

Decisions regarding effective preoperative and postoperative therapy may be facilitated by information from the patient regarding the drugs he tolerates and responds to in contrast to those agents which have been ineffective. Because of the possible allergic role and the frequent in-hospital use, sensitivity to salicylates, penicillin, the "-caines" and other drugs should be determined. Personal problems, fears and anxieties should be openly discussed during this period of surgical stress.

The physical examination should clarify the current asthmatic activity of the patient and other medical disorders. In particular, chest examination may also identify coexisting pulmonary disorders; significant findings include symmetry and expansion of the thorax, regional breath sounds (intensities or changes), the presence of rales or rhonchi, and the degree of wheezing. During an acute attack, hyperinflation of the thorax will produce physical findings similar to those of emphysema, but must be interpreted with this qualification. Cyanosis may reflect significant arterial hypoxemia. Clubbing or signs of cor pulmonale can alert the physician to associated chronic bronchitis, bronchiectasis and emphysema. Complete cardiovascular appraisal is also necessary.

The routine laboratory tests necessary for preoperative evaluation should include the following: chest x-ray (inspiratory and expiratory films to assess air-trapping, vascular markings, cardiac size, infiltrates), ECG, hemoglobin, white blood cell count and differential (to clarify allergic eosinophilia or infectious neutrophilic shift to the left), urinalysis, BUN and blood sugar. The sputum examination will be considered in the section of this chapter titled "Preoperative Preparation."

In addition to the history, physical examination and routine laboratory data, preoperative pulmonary physiology studies are valuable in defining the level of impairment and reserve, and will provide some indication of operative risk.[6] Pulmonary function studies will provide *quantitative* parameters in the preoperative assessment and will be sequentially valuable if pulmonary complications ensue.

The simple forced expiratory vital capacity (FVC, FEV) defines total displaceable lung volumes, the degree of airway obstruction and the presence of reversible bronchospasm. The following values are presented as guidelines suggesting significant airway obstruction, reduced vital capacity or ventilated lung volumes:

A. Reduction in total FEV or slow vital capacity (SVC) to 50 per cent of the predicted value. Values from 50 to 70 per cent of the predicted represent mild to moderate impairment, but still require therapeutic consideration.

B. Reduction in maximum voluntary ventilation (MVV) to 50 per cent of the predicted values.

C. Reduction in maximum expiratory flow rate (MEFR) (200-1200 cc) by 50 per cent of the predicted, or to less than 200 L/min.

D. Absolute reduction in $FEV_{1.0}$ to 1.0 L-1.2 L, or less than 50 per cent of

the observed FEV or predicted $FEV_{1.0}$ (obstructive airway disorder pattern).

E. Reduction in peak expiratory flow rate (PEFR) (Wright Meter) to 50 per cent of the predicted. In general, for all the above tests, values less than 50 per cent of the predicted are significantly reduced, those from 50 to 65 per cent are moderately reduced, and 65 to 80 per cent mildly reduced.

Following bronchodilator aerosols, changes in the FEV and/or air flow parameters should be determined. An improvement in FEV_{total} or $FEV_{1.0}$ by 10 to 15 per cent or greater is significant and indicates reversible bronchial obstruction. The $FEV_{1.0}$ may improve while the FEV_{total} changes minimally indicating an improvement in measurable air flow parameters but not vital capacity. This indicates a decrease in airway resistance and reduced work of breathing for a given minute or alveolar volume. One should not evaluate bronchodilators by percentage increase in timed expired values alone since the FEV_{total} and first second ($FEV_{1.0}$) and third second ($FEV_{3.0}$) volumes may improve proportionately.

The other major data which should be obtained are the arterial blood gases and pH. While alveolar and dead space ventilation, work of breathing, distribution of gases, etc. are important parameters, for practical purposes the direct measurement of arterial blood P_{O_2} P_{CO_2} and pH is the simplest laboratory method for assessing the *overall function* of all the ventilatory processes when significant impairment exists. The delineation of pulmonary insufficiency (hypoxemia $P_{O_2} < 85$ mm Hg) or ventilatory failure (hypoxemia with hypercapnia $P_{CO_2} > 45$ mm Hg, pH $\pm$ compensated) may thus be correlated with clinical events. Mild degrees of hypoxemia are encountered in many patients with chronic stable asthma, secondary to abnormal ventilation/perfusion ($\dot{V}/\dot{Q}$) relationships. Thus, in the chronic stable state with minimally active asthma, a Pa_{O_2} (arterial oxygen tension) of 70 to 80 mm. Hg (depending upon local laboratory normal Pa_{O_2}) can be considered mildly abnormal. With exercise a further drop in Pa_{O_2} and/or rise in Pa_{CO_2} (arterial carbon dioxide tension) will suggest limited reserve.

As a consequence of hypoxemia, anxiety and increased expiratory (and inspiratory) resistances, hyperventilation with hypocapnia ($P_{CO_2} < 38$ mm Hg) may be present. In any patient with a reduced FEV and significant airway obstruction, mild hypoxemia with mild hyperventilation may be viewed as reflecting increased respiratory work. This abnormality may be reduced by appropriate therapy. In an acute deterioration of bronchial asthma, similar mechanics and blood gas data may be observed, and the clinical pattern with *sequential* blood gas values may be useful. We have data to indicate the importance of such serial arterial blood gas and pH determinations during acute bronchial asthma.[7] An asthmatic patient with active bronchospasm often shows some hypoxemia, hyperventilation with a low Pa_{CO_2} and a mild respiratory alkalosis. Subsequent arterial blood samples may reveal a P_{CO_2} of 40 mm Hg and pH of 7.40. These values may indicate that the patient is either (a) improving or (b) significantly *deteriorating*. In the latter instance, the now "normal" Pa_{CO_2} and pH represent progressive alveolar hypoventilation. Subsequently many of these patients will "cross over" from a hyperventilation

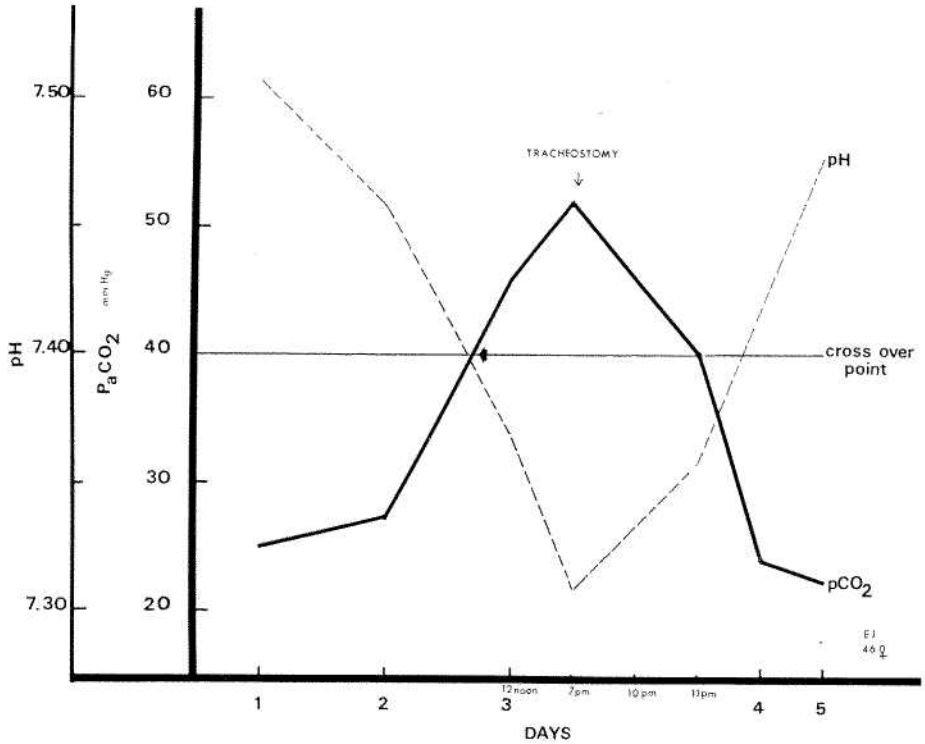

FIG. 1.—Arterial $Paco_2$ and pH data in a 46-year-old Negro female with status asthmaticus. Initial arterial gas studies revealed hypocapnia ($Paco_2$—25 mm Hg) and respiratory alkalosis (pH_a—7.51). Progressive status asthmaticus with fatigue and clinical deterioration ensued, and, on the third hospital day, arterial blood gases progressed to the "crossover" phase with "normal" $Paco_2$ and pH values. Failure to recognize the significance of these changes and to intensify treatment appropriately at this critical period was associated with frank respiratory acidosis requiring tracheostomy and mechanical ventilatory support.

phase to normal blood gas profile, and then into frank respiratory acidosis with its attendant increased mortality or morbidity related to the need for tracheostomy and ventilatory support (Fig. 1).

There have been reports describing hypoxemia occurring after therapeutic isoproterenol or aminophylline in bronchial asthma and attributed to deteriorating ventilation/perfusion relationships.[8,9] Most of these data reveal a mild drop in the Pao_2 of about 10 mm Hg. The full significance of this observation is not yet clear; however, such falls in Pao_2 must be accepted in the context of reduced airway resistance and work of breathing. Fortunately, this hypoxemia may be easily corrected by appropriate administration of oxygen, usually administered in the acutely or seriously ill patient with bronchial asthma.

Other physiologic tests such as lung volumes, distribution of inspired gases, specific measurement of airway resistance and diffusion should be reserved for evaluation of the more complicated case. Differential bronchospirometry may be a valuable aid if lung resection is planned. Interestingly, a restrictive type of FVC curve may be seen in bronchial asthma. This is due to increases in

residual volume as the result of air-trapping mechanisms which cause a reduction in vital capacity and lung compliance. Thus, it has been suggested that serial measurements of the residual volume compartment are of value in evaluating acute airway obstruction when the FVC is reduced.

Precipitating and Risk Factors

Successful management requires consideration of various precipitating factors and the nature of the patient's response, both physically and psychologically. Where feasible, removal of offending allergens may be beneficial in preventing attacks. Environmental agents such as dusts, molds and pollens cannot be entirely avoided. Hyposensitization therapy with commercially available extracts is impractical in the immediately preoperative period. Elective surgery should be planned in consideration of seasonal allergic factors if possible. For example, resection of nasal polyps, usually a minor procedure, may result in status asthmaticus, if it is performed during the patient's allergic season.

Once the asthmatic pattern develops, multiple precipitating factors, often unrelated to the original cause, may interact and be responsible for further deterioration into status asthmaticus:

1. *Infection*: Viruses, bacteria, fungi (bronchitis, pneumonia).
2. *Allergic factors:* Pollens, animal danders, dusts, foods, drugs, vaccines.
3. *Irritative factors*: Dusts, fumes, strong odors, smoke (air pollutants).
4. *Trigger mechanisms:* Sino-bronchitic disease, nasal polypi, gastric aspiration, otitis media, weather and humidity changes, laughing, physical exertion.
5. *Emotional*: Stress, fatigue, surgery.

Since a search for responsible agents is difficult and often of variable success, emphasis on full physiologic and drug support therapy is necessary.

In the preoperative evaluation, consideration of additional risk factors that might further increase the operative and postoperative morbidity and mortality is necessary. Of great importance is the presence of other respiratory disorders. Pulmonary problems are an important cause of operative and postoperative mortality.[10] It is reported that two-thirds of all patients with emphysema and bronchitis develop postoperative atelectasis and/or pneumonia.[3] The routine preoperative evaluation should also be directed towards detecting unsuspected disorders such as anemia, diabetes mellitus, gastrointestinal bleeding and renal, cardiac and pulmonary embolic disease, since these may stress pulmonary reserve and thereby increase the incidence of operative and postoperative complications.

All patients should be encouraged to stop smoking during the preoperative period to control cough and sputum production as well as to improve the bronchial mucociliary and alveolar macrophage defensive mechanisms.

Obesity can be associated with a number of physiologic abnormalities which may influence the frequency of postsurgical respiratory complications. An increased O_2 uptake and CO_2 output, reduced vital capacity, abnormalities of $\dot{V}/\dot{Q}$ relationships with resulting hypoxemia, and an increase in the work of breathing all contribute to decreased respiratory reserve in these patients.[11] The presence of a high diaphragm and the recumbent position predispose to the development of pneumonia and atelectasis.

The site of operation is an important risk factor, with the highest incidence of complications following thoracic and upper abdominal procedures.[10] Many of these patients may have ventilatory problems in the postoperative period despite previously adequate ventilatory function. There is also a strong correlation between complication rate and increasing duration of anesthesia.[4] Further risk factors include the male sex, increasing age, and other debilitating medical disorders; appreciation of these factors will clearly aid in intelligent management.

Preoperative Preparation

The mild, asymptomatic, asthmatic patient may be managed with minimal therapy. A discussion of the problems and assurance by the physician that the patient's pulmonary status will be closely observed can allay anxiety. The use of rectal or intravenous aminophylline solution, administration of bronchodilator aerosols by means of intermittent positive-pressure breathing (IPPB) and employment of humidification therapy for a few days may alleviate bronchospasm with improvement of inspired gas distribution, and simultaneously facilitate their use if required in the postoperative period. However, the more symptomatic patient should be admitted electively for intensive preoperative evaluation and treatment. A preoperative regimen will bring the individual to an optimal physiologic level and concomitantly introduce techniques which may be required in the event of pulmonary complications.

Evaluation of the nature of the patient's sputum will aid the planning of the preoperative management. Gross and microscopic examination should be performed, with the findings related to the actual clinical status of the patient. When possible, the patient's ability to clear secretions should be observed. Although thick and sticky sputum may be difficult to clear from the bronchial lumen, it is not unusual for thin, stringy secretions to also present considerable difficulty. Patients who do not raise sputum but who have rales or rhonchi are suspected of having silent inspissated plugs and often are in great trouble from such secretions. The presence or suspicion of such secretions requires a vigorous therapeutic regimen to promote clearance and to control the causes for their production.

Among the general therapeutic measures, *hydration* is perhaps the most important. Oral fluids may be sufficient, but parenteral fluids should be used as indicated. Aerosol therapy with water or normal saline may be administered by standard Venturi-type or ultrasonic nebulizers. Whether such therapy actually increases the water content of the bronchial secretions is not known, but clinical experience strongly supports such measures. Water may act as a lubricant permitting separation of the sputum plugs from the bronchial wall. In our experience Alevaire offers no advantage over normal saline or water. *Expectorants* (agents that facilitate the raisability of sputum) should also be employed. If oral medications are possible, then glyceryl guaiacolate (Robitussin) in doses of 300 to 600 mg every four to six hours and/or iodides (saturated solution of potassium iodide or iodinated glycerol—Organidin) in doses of 10 to 30 drops three to four times a day should be given. If it is limited to parenteral

therapy, sodium iodide may be administered in doses of 1 to 2 Gm/L intravenously, provided sodium loading or iodide idiosyncrasy is not a problem.

Physical therapy will be of great value once the above measures are established. It should be introduced during the preoperative period and thus may be more effective postoperatively. With the patient properly positioned, utilizing the forces of gravity, chest tapping and encouragement to cough, effective bronchial catharsis may ensue. Excessive coughing must be avoided since this may precipitate bronchospasm. Similarly, any irritative and unproductive cough may be subdued by preoperative medications or antitussive agents such as chlophedianol (ULO), pipazethate (Theratuss), dextromethorphan hydrobromide (Romilar Hydrobromide), promethazine (Phenergan), or codeine. In extreme situations, *mechanical removal* of inspissated secretions may be necessary, but must always be approached with great care. Tracheal suction, instillation of saline in small amounts via nasopharyngeal or transtracheal catheter, controlled bronchoscopy and lavage or, rarely, elective tracheotomy may have to be resorted to in the preoperative preparation of some individuals solely for the control of their secretions.

Specific therapeutic measures may be indicated by the type of sputum the patient is producing. The more allergic or purely "asthmatic" type is grossly characterized by its mucoid properties (a ground-glass and gelatinous appearance). The viscosity of sputum is generally attributed to conglomerates of mucopolysaccharide and mucoprotein molecules. The cellular characteristics can be readily examined microscopically with a small fragment of fresh, unstained sputum under a cover-slip with reduced illumination. A drop of a dilute, buffered, aqueous solution of crystal violet will improve visualization. The cellular profile consists of a large proportion of eosinophils, macrophages, usually some neutrophils and bronchial epithelial cells which are often swollen, sometimes retaining their cilia, and occasionally in tissue fragment containing 50 to 400 cells (Creola bodies).[12] There are usually no bacteria on gram stain. When this type of sputum is present, the specific therapy should be directed toward the allergic factors stimulating such secretion. Avoidance of allergens, antihistamines and steroids may be beneficial and significantly reduce the sputum volume. Although Mucomyst (*N*-acetylcysteine) appears to act specifically on such mucoid gels by opening disulfide linkages, it must be used with caution in asthma since it commonly induces bronchospasm. The addition of a bronchodilator (0.2-0.5 cc of 1:200 isoproterenol) to a 10 to 20 per cent solution of Mucomyst may reduce this hazard. When bronchial infection or nonspecific chronic bronchitis is a factor, the sputum has different characteristics. Although on gross examination it may still appear mucoid, it will more likely be grey, yellow or green. The viscosity in such sputum is related to both desoxyribonucleic acid fibers and mucopolysaccharide chains. Microscopically, the cellular content will consist predominantly of neutrophils, a fair number of individual degenerated bronchial epithelial cells, and variable numbers of macrophages and eosinophils. Bacteria will usually be evident on gram stain and culture. Infected sputum containing *Diplococcus pneumoniae* and/or *Hemophilus influenzae* may be treated with ampicillin (2 to 4 Gm/day) or tetracycline (2 Gm/day) for 5 to 14 days as indicated by the sputum and

clinical response. With more serious clinical infection, the use of intravenous penicillin G (10 to 20 million units/day) with or without streptomycin (1 Gm/day) may be required. With gram-negative bacilli, antibiotic treatment should be based on drug-sensitivity studies. Dornavac may be useful in DNA-rich specimens in decreasing the viscosity when used in doses of 50,000 to 100,000 units four times a day either directly instilled or aerosolized. When the sputum is of a mixed allergic-infectious nature, combined therapy is required.

Bronchodilators

Bronchodilators are an essential component of management.[13] For all but the mildest or asymptomatic cases, we employ aminophylline both for preoperative preparation and during the surgical procedure if significant bronchospasm continues despite full supportive measures. The oral and rectal routes of administration may be utilized in mild asthmatics during the preoperative period. Intravenous aminophylline is employed in patients with moderate to severe bronchospasm during the preoperative period with dosages adjusted to the clinical response, usually not exceeding 1.5 Gm/24 hrs. During surgery, intravenous aminophylline 0.5 Gm/L may be administered slowly, at a rate not to exceed 2 cc/min. Side effects to be avoided include nausea, emesis, palpitation and hypotension. Hyperventilation, mild hypoxemia and cardiac irregularities have been reported after rapid infusions of aminophylline, particularly in cardiac patients.

Also employed are the sympathomimetic bronchodilators including aerosolized isoproterenol (Freon propellant inhalers, nebulizer-aerosols or IPPB units with up to 0.5 cc of 1:200 solution in 2 cc saline, 3 to 4 times per 24-hour period), or subcutaneous doses of epinephrine (0.3 cc of a 1:1000 solution administered as indicated) in bringing preoperative asthma under control. Additional doses must be used with caution, particularly in the presence of cardiac, hypertensive or cerebrovascular disease.

Steroids

The need for steroid administration arises frequently. Its goal is the reduction of bronchial-bronchiolar edema, cellular inflammation and mucous secretions, thereby reducing airway obstruction which may contribute to acute respiratory insufficiency and/or asthmatic exacerbations during surgery. Relative adrenal insufficiency must be avoided in patients on chronic steroid therapy. Routine pituitary-adrenal axis stress assays are not practical. Individuals not on corticosteroids and responsive to the usual supportive therapy will not require these drugs. Patients who require steroids for adequate preoperative control or who have been on chronic therapy should receive a booster dose, 100 to 200 mg (or equivalent) of hydrocortisone or more on the day of surgery followed by return to previous dosages by gradual tapering-off. The exact biologically active dose is empirical; however, steroid dosages should be sufficient to produce eosinopenia (<50 cells/mm^3). Preferably, if such individuals require continuous steroid therapy, alternate day schedules before and after surgery, with the total dose administered in the morning, will reduce the incidence of undesirable side effects such as gastrointestinal bleeding, diabetes mellitus, hypokalemia,

osteoporosis, psychosis, electrolyte abnormalities, fluid retention, hypertension, spread of tuberculosis, fungal disease or bacterial infections. Particular attention to bacterial infection is mandatory when steroids are administered. The use of antacids and appropriate antituberculous drugs is an important consideration. Finally, normal serum potassium should be maintained with supplements of potassium chloride.

Preanesthetic Medications

Preanesthetic medications must be employed cautiously because of their ventilatory depressant potential. Morphine or meperidine may reduce ventilatory response to hypercapnia; promethazine (Phenergan) may potentiate this effect. Parasympathetic blocking agents such as atropine or scopolamine, while possessing some bronchodilator activity, may create thick, dry bronchiolar mucous plugs by decreasing liquid secretions and may thereby contribute to postoperative atelectasis or pneumonia.

The decision regarding anesthetic agents should be made by the anesthesiologist in consultation with the personal physician. In general, these agents are central depressants, and adequate ventilation must be assured during and following the anesthetic period. Hypoxemia or respiratory acidosis may result in pulmonary vasoconstriction. Weiss[14] has shown that gastric contents may be aspirated in about 20 per cent of patients with general anesthesia; this may provoke reactive bronchospasm. The defense mechanisms of the respiratory system may be altered by narcotics, tubes or dehydrating anesthetic gases. Thus, the warming, humidifying and filtering action of the upper respiratory tract, mucociliary function and cough reflexes may be impaired. The use of cool or dry anesthetic gases in conjunction with preoperative dehydration or the excessive use of belladonna derivatives, endotracheal intubation, respiratory depressants, adverse body positions or cough-suppressing narcotics may impair the fluidity and viscosity of secretions and create conditions for atelectasis or postoperative pneumonitis. Thus, once an anesthetic agent is selected, a major concern is to provide adequate warming and humidification of the inspired gases during the operative procedure concurrently with adequate oxygenation and alveolar ventilation.

Because of a lack of data and the numerous anesthetic techniques, no unified approach to the anesthetic management of the asthmatic patient has been established. Considerations of inductive agents, maintenance anesthesia, method of administration, type of muscle relaxant, and use of endotracheal intubation contribute to the problem. However, the asthmatic patient is a surgical risk and requires very careful selection of agent and methods.

Conduction (local) anesthesia may be a preferable approach since it eliminates the use of irritant gases and endotracheal intubation, which may provoke cough or bronchospasm. In addition, gross alveolar hypoventilation will not occur unless spinal motor blockade reaches the C_3, C_4 and C_5 nerves. A study by Moir in patients with chronic obstructive lung disease revealed that proper spinal or epidural anesthesia will not abolish an effective cough.[15] The level of spinal anesthesia should be below T_6 since a high incidence (83 per cent) of pulmonary complications and depressed ventilation may result from reduced

thoracic musculature function.[4] Interestingly, wheezing developed in 1.9 per cent of asthmatic patients receiving regional anesthesia.[1] Thus, even this approach is not entirely free from bronchospastic complications. In addition, patients with clinically active asthma at the onset of surgery may fail to improve with regional anesthesia.[1] Other problems with conductive agents include anaphylaxis, sympathetic paralysis with depression of endogenous adrenalin release, and increased anxiety because of manipulation in an awake state.[16] Therefore, conductive anesthesia must be employed with caution during active asthma, but may be useful for local surgical problems whereby general anesthesia may be avoided.

Among the inductive agents, diethyl ether and halothane are the drugs of choice for general anesthesia in asthma.[1,4] Ether has been employed for anesthesia and treatment of status asthmaticus.[17] In light surgical anesthesia, ether does not produce respiratory depression; it may in fact increase minute volume, until arterial ether levels approach 170 mg/100 cc.[18] However, certain problems arise: prolonged induction time, stimulation of profuse and often viscid tracheobronchial secretions, and the deep phase of anesthesia required for bronchial muscle relaxation.[4] Halothane, on the other hand, is not irritating to the airway, does not stimulate tracheobronchial secretions,[19] and is associated with rapid induction and emergence from anesthesia.[20] Like ether, halothane can relax bronchial smooth muscle with a significant increase in dynamic lung compliance and bronchial distensibility[21,22]; insignificant increases in dead space volume appear to result from this bronchorelaxation. In general, in asthmatic patients, it has been safely employed in induction and maintenance of anesthesia and has the advantage of rapidly relieving acute bronchospasm developing during surgery. In those patients with clinically active disease prior to anesthesia, halothane has been effective in reducing the asthmatic episode and, in this respect, seems superior to ether.[1] Surfactant activity appears unaltered by the clinical concentration of conventional anesthetic agents[23]; this point is yet unresolved.

The choice of a muscle relaxant in patients with bronchial asthma is a matter of controversy because of the release of histamine by *d*-tubocurarine.[24] Periodic case reports relate bronchospasm with this drug; yet other authors have stated that curare neither precipitates nor aggravates preexisting asthma.[2] Since the safety of the drug in bronchial asthma has not been completely clarified, it should be administered with caution, and preferably should be replaced by gallamine (Flaxedil) or succinylcholine, which apparently do not release histamine.

Shnider and Papper[1] emphasize that the introduction of an endotracheal tube with or without the use of topical tracheal anesthesia is a common cause of acute asthma. Reflex bronchoconstriction has been demonstrated in cats during barbiturate anesthesia by an intratracheal catheter, by irritating vapors acting on deep lung receptors or by sudden distention of bronchi with positive pressure.[25] However, a tube will be necessary in the presence of bronchospasm or significant secretions; otherwise, it should be avoided if possible. Thus, in view of the complexities involved in asthma patients and the necessity for preoperative medications and anesthetic agents (local or general), individualized

consideration will be required in each case. Knowledge of the potential dangers of such agents demands their judicious use. Periodic clinical assessment and physiologic monitoring (i.e., blood gas and pH) in difficult cases will minimize complications.

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