Paparella: Volume III: Head and Neck

Section 2: Disorders of the Head and Neck

Part 1: Nose and Paranasal Sinuses

Chapter 6: Allergic Rhinosinusitis: Diagnosis and Treatment

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Every organ system in the human body is capable of an immunologic response and, therefore, is capable of developing allergic dysfunction and clinical disease. It follows that practitioners of every specialty of medicine will have to develop the expertise to recognize, diagnose, and treat these allergic syndromes. The role of the general allergist-immunologist should be that of a true specialist dealing with complicated cases and syndromes of unusual immunological disorders. He or she must teach the recognition, diagnosis, and treatment of common allergy disorders to all specialists so that this important field can be expanded rather than contracted.

The general otolaryngologist deals with perhaps the most common shock organ of allergic disease, the upper respiratory tract, and in particular the nose and paranasal sinuses. The otolaryngologist is, therefore, ideally suited to function as a regional allergist treating both the medical and surgical disorders caused by immunologic dysfunction.

The nasal chamber and surrounding nasal sinuses are by far the most common shock organs of allergic disease; however, the principles of diagnosis and treatment to be outlined in this chapter are also applicable to allergic disorders of the ear, larynx, pharynx, and central nervous system. Problems such as Ménière's disease, fluctuating tinnitus, chronic external otitis, chronic headache, chronic pharyngitis, and many other chronic symptoms will respond dramatically to proper allergic diagnosis and treatment.

The History of Otolaryngic Allergy

Descriptions of human disease suggesting a food or inhalant allergic mechanism have been offered for centuries; however, the first medical description of an allergic disease was by Bostock of Guy's Hospital, London, in 1819. He described a condition that he called seasonal catarrh, which was later called hay fever. In 1872, Morrill Wyman of Harvard Medical School first recognized ragweed pollen as being the cause for autumn catarrh, and the following year an English physician, C. H. Bladsley, presented a study that demonstrated grass pollen as a cause of asthma. The science of immunology developed along different lines, and the two were brought together in 1906 when a Viennese pediatrician, Clemens von Pirquet, first used the world allergy to refer to an altered response to any foreign agent in the environment. This broad definition of allergy is still employed by the general public and the majority of physicians, except for the general allergists who maintain that allergy refers only to disorders mediated by the

immunoglobulin IgE.

In 1911, the first systematic use of desensitization was described by Noon of London. His method of slowly increasing doses of allergenic extract over a period of months is still the basis for immunotherapy used by most general allergists. Prausnitz and Küstner in 1921 described the presence of a transferable skin sensitizing factor in the serum, which they called reagin. An exact nature of reagin or skin sensitizing antibody was not known until 1966 when IgE was discovered by Ishizaka and Johansson. This discovery has led to the increasingly accurate diagnostic in vitro methods in use today.

The field of otolaryngologic allergy began in 1936 with the publication of French K. Hansel's book, *Allergy of the Nose and Paranasal Sinuses.* He devoted the remainder of his life to teaching otolaryngologists allergic diagnosis and treatment, as well as to do doing pioneer work in the study of nasal psychology and optimum dose therapy for each specific agent. In 1940, Herbert Rinkel standardized Dr. Hansel's method by separately titrating each antigen using one to five dilutions of increasing strength with intradermal skin testing. This superior method of skin testing for inhalant allergies has persisted to this day and has been proved by double-blind studies to be the most accurate method of diagnostic skin testing.

Dr. Rinkel was also the first allergist to accurately describe the natural history of food allergy, and by so doing first conceived the challenge feeding tests that are still a basic diagnostic tool in use today. Unfortunately, Rinkel's explanation of the true nature of food allergy and its importance in diagnosing disease in many organ systems has not been universally accepted. His designations of unmasked and masked food allergy, depending largely on the frequency of ingestion, must be thoroughly understood by the physician if he or she is to accurately diagnose the patient and design a long-term plan for treatment. In 1951, Dr. Theron Randolph first described chemical sensitivity as a major source of chronic illness. These men have been responsible for the development of modern techniques of diagnosis and treatment of allergic disorders.

Basic Immunology

Advances in the field of immunology have continued to provide a better understanding of the mechanisms involved in various types of immune diseases. In spite of this vast knowledge, we still do not totally understand the biochemical mechanisms and abnormal pathways involved. For this reason, we have failed to develop specific in vitro tests (with the exception of determining accurate levels of specific IgE in inhalant allergy). The patient who has inhalant food or chemical sensitivities is subject to complex immunologic events involving many cell types, chemical mediators, and immunoglobulins. Immunologic mechanisms of hypersensitivity are classified by Gell and Coombs into four types:

1. *Type I* (reaginic or immediate hypersensitivity): The antigen binds to two molecules of IgE (or IgG4) attached to the receptor site on the surface of the basophil or mast cell. This causes a release of chemical mediators from these cells, which causes vasodilatation and vascular

permeability. Examples of this reaction are allergic rhinitis, anaphylactic shock, and bronchial asthma.

Type II (cytotoxic or cytolytic reactions): Either IgG or IgM binds to the surface of the cell-bound antigen, activating the complement cascade and causing lysis or agglutination of the target cell. Examples are hemolytic anemia and hemolytic disease of the newborn.

3. *Type III* (immune complex reactions): Antigen-antibody combines with complement to form immune complexes, which are deposited in tissue. Vasoactive amines are liberated, and inflammation of the involved tissue occurs. Examples are autoimmune disease, serum sickness, and some types of nephritis.

4. Type IV (delayed hypersensitivity): Sensitized T-lymphocytes cause target cell injury or death by direct cell attachment or release of mediators. Examples are contact dermatitis and rejection of grafts and tumors.

The basic cell types of the immune system are the polymorphonuclear leukocyte, eosinophil, monocyte, macrophage, and various types of lymphocytes. A detailed description of the allergic response is beyond the scope of this text but can be found in many textbooks of immunology. Although there is increasing evidence that all types of immune mechanisms can take place in the organ systems seen by otolaryngologists, the type I reaction mediated by IgE is the most common, particularly in the nose and paranasal sinuses. The basophil and mast cells are the target cells of the type I allergic response. As a result of the bridging of antigen and antibody on the surface of the mast cell, chemical mediators are released. They include histamine, leukotrienes, and the eosinophilic chemotactic factor of anaphylaxis. These mediators cause vascular permeability, with edema, vasodilatation, and bronchoconstriction.

Plasma cell production of the five immunoglobulin classes provides the basis of antibody reaction in humoral immunity. These plasma cells come from B-lymphocytes. The B-lymphocytes has specificity for the recognition of antigens by their immunoglobulins, which are on the surface of the cell. After antibody bonds to the antigen, the B-cell can differentiate into clones of plasma cells that are immunologically specific for that antigen. The five classes of immunoglobulins are IgG, IgA, IgM, IgD, and IgE.

A second pathway of immune response is cell-mediated immunity and involves T-lymphocytes, subclassified as T-suppressor cells, T-helper cells, and natural killer cells. The T-helper cell acts to amplify antibody response, whereas the T-suppressor cell suppresses antibody formation and response. The T-cell and natural killer cell effect direct cytotoxicity and delayed hypersensitivity by releasing mediators called lymphokines or by directly attaching to the target cell.

In skin end point titration, increasing doses of an antigen are injected until a wheal and flare response is produced. This reaction results from the release of chemical mediators from mast cells, which causes edema and vasodilation. Immunotherapy is begun with the weakest

dilution causing a positive reaction, known as the end point. Stronger doses are given until relief or symptoms occur. The theory of immunotherapy is to block mediator release by increasing IgG4 and decreasing IgE. If treatment is effective and takes place over a span of 1 to 4 years, it may result in complete remission of symptoms without further therapy. Immunotherapy is instituted when symptoms correspond with specific allergen exposure, and positive test results confirm the presence of abnormal levels of specific IgE antibody.

Understanding the Natural History of Inhalant, Food, and Chemical Allergy

From a clinical standpoint allergic disease can be subdivided into three causative classes: inhalants, foods, and chemicals. Since inhalant allergy produces an immediate cause-and-effect type of reaction that is obvious to patient and physician, it is the class most readily recognized. Because of the natural history of food and chemical sensitivity is poorly understood and because there are no accurate in vitro tests, these classes are less frequently recognized as being the cause of chronic disease. It is becoming increasingly apparent that food and chemical sensitivity is probably as frequent a cause of chronic respiratory disorders as is inhalant allergy. There are two major types of food allergies: fixed and cyclic. A fixed food allergy is one that occurs each time the food is consumed, no matter how long it has been avoided. Cyclic food allergy is one in which the reaction is related to the frequency and quantity of consumption. Increased frequency of eating leads toward sensitivity, avoidance leads toward tolerance. In the past, Rinkel explained cyclic food allergy by using the term *masking*, but Randolph's term of *food addiction* more adequately described the development of a cyclic food allergy. Although the gastrointestinal passage time may be less than 24 hours, the biochemical effects of ingesting food can last up to 5 days. That is why the patient who eats a food infrequently does not offer a diagnostic problem, since each dose hits the gastrointestinal tract in an unprepared state and the cause and effect is obvious to the patient. If, however, the patient eats the food constantly (eg, common foods such as milk, wheat, eggs, coffee, corn, and so on), the dose of food reaches the gut while the previous doses are still reacting. The reaction is not clear-cut but a continuance of previous symptoms. Because the patient was probably not allergic to the food when he or she first began to ingest it, the slowly developing symptomatology is masked, and the patient does not correlate the ingestion of the food with the chronic symptoms. To further complicate the problem, the initial ingestion of an allergenic food may produce a stimulatory central nervous system reaction that the patient perceives as beneficial. This phase always precedes the undesirable symptoms and the patient, remembering the stimulatory phase, is then encouraged to ingest the food again. Since the repeated ingestion of a food makes the allergic reaction increasingly severe, the patient must ingest the food more frequently to remain in the stimulatory phase and thus becomes addicted to the very food that is causing the other symptomatology. If, at this point, the patient suddenly stops eating the offending food, he or she may go into a stage of withdrawal. The withdrawal symptoms vary in severity and duration, depending on the individual. When this stage ends, usually after 3 to 5 days, the patient will enter a hyperactive reactive phase. During this stage, if the offending food is again consumed, there will be a clear-cut and usually severe reaction. The individual deliberate feeding test is based on this sequence of events. If the patient continues to omit the food from the diet, he or she will usually slowly lose the allergy to that particular food. To achieve this stage of tolerance may sometimes take months or even years. In many patients,

it may never happen. If the patient achieves tolerance for a food, he or she may then again begin to ingest the food, but only intermittently. The patient is advised to leave the offending food out of the diet for at least 3 months. Usually the allergy will not develop again if the food is not eaten more frequently than once in 4 days.

A safe interval, however, may vary for different foods. The patient must be warned about establishing safe intervals of ingestion. Foods that have never caused reactions in the past may be consumed at closer intervals than foods to which the patient has become allergic.

The patient who does not follow this type of rotary diet (Appendix A) and does not diversify into many different foods will again slowly exhibit the original problem.

The development of chronic chemical sensitivities is also based on frequency of exposure and has the same natural history as that described for food allergy. In addition, chemical sensitivities can be started by a large dose of chemical through inhalation, ingestion, or contact. The mechanism of altering the immune system from such a large dose is unknown but has been documented repeatedly in many hundreds of patients.

Diagnosis

A patient preserving with chronic nasal complaints deserves an extensive and thorough workup. This includes a detailed history, a precise examination, and at least screening radiology studies. Physical abnormalities found on the initial examination are confirmed by use of the fiberoptic or rigid nasopharyngoscopes, and any suspicious abnormalities on conventional sinus x-ray films are confirmed by the use of both axial and coronal computed tomography (CT) scan. If allergy is suspected as the basic cause, an organized plan of diagnosis and treatment can be started while any infection is being brought under control and any elective surgical procedure is being scheduled.

This orderly plan of diagnosis and treatment should require a minimal expenditure of time from the physician and will also be cost-effective. If the otolaryngologist does not desire to diagnose and treat allergic disorders, he or she must certainly be able to recognize them, since failure to control an allergic reaction in a patient will result in recurrence of symptomatology, regardless of how effectively and carefully surgical therapy is performed.

If the physician elects to actively diagnose and treat the allergic patient, it must be done completely and thoroughly. Half-hearted attempts to immunotherapy or guessing which food the patient may react to will result in frustration for both patient and physician.

Allergic History

Patients presenting to the rhinologist with nasal complaints invariably have a long history of allergy. In treating any allergic disorder, it is of paramount importance to completely rule out other causes of the patient's symptoms, particularly hidden infections and neoplasms. The

diagnosis, therefore, is frequently one of exclusion of other disease entities.

When nasal symptoms are chronic, the patient frequently presents to the otolaryngologist with various disorders demanding surgical intervention. The cause of these disorders, however, is frequently overlooked so that recurrence of disease is extremely common, leading to more and more destructive surgical procedures.

The typical case of allergic rhinitis will present with seasonal variations of symptoms, the three most common being obstruction, rhinorrhea, and sneezing. These symptoms are often accompanied by irritation of the eyes and symptoms of lower respiratory disease. Allergic nasal problems can also be caused by food and chemical sensitivity, and questionnaires to alert the otolaryngologist to these conditions can be found in Appendices B and C.

A high percentage of adults with food allergies have a history of feeding problems during infancy, as well as croup, colic, eczema, frequent upper respiratory infections, bronchitis, and chronic serous otitis media in early childhood. In addition, the food-sensitive person often is an inordinately fatigued person and functions best as the day wears on. Symptomatology that varies in severity from day to day and tends to involve many organ systems is also suggestive of food allergy.

The family history and past history of the patient are also of great importance. If anatomic deformity or chronic infection is the sole cause of the patient's problem, a family and past history will usually be normal, and the patient will be able to identify the exact time his or her symptoms began.

Inhalant Allergy Diagnosis

Since the diagnosis of inhalant allergy can be made much more efficiently and accurately than that of food and chemical allergy, it is always dealt with first. To establish the diagnosis, an inhalant screen is performed using either skin testing or in vitro techniques. If the patient is tested for the eight most common inhalant antigens found in the geographic area, the degree of reactivity will predict if the diagnosis of inhalant allergy is important. If no reaction to any of the eight antigens is found, the diagnostic workup can proceed immediately to the food and chemical category.

If the inhalant screen results are unquestionably abnormal, a complete testing program is outlined for the patient, with explanation of the subsequent desensitization program. This testing program can be performed using serial end point titration or the newer in vitro techniques, such as radioallergosorbent test (RAST), fluorescent antibody test (FAST), IP, MAST, or BEST. The importance of the otolaryngologist first being educated in skin testing before using in vitro methods cannot be overemphasized. Most allergenic extracts are not standardized and are produced by many commercial companies. Although the in vitro instruments are becoming increasingly accurate, the physician must be able to relate the in vitro results to the antigens used for immunotherapy. In addition, by performing the inhalant screen by skin testing on a new

patient, it demonstrates visibly to the patient that he or she is, in fact, allergic to the test antigens and encourages him or her to undergo a treatment desensitization program.

Serial end point titration is defined as the diagnostic technique of determining the amount of sensitivity to each inhalant antigen. The method endorsed by the American Academy of Otolaryngic Allergy is that proposed by Rinkel and described by him in detail in a series of articles published in the Archives of Otolaryngology in 1962. Using Dr. Rinkel's technique, the concentrated commercial extract is diluted one to five times to make six separate extracts that are numerically labeled, 1 being the most concentrated and 6 being the most dilute. Testing is started with a No. 4 dilution, unless the patient has a history of severe reaction, such as asthma or angioneurotic edema; in such a case, testing would start with a No. 6 dilution. Stronger dilutions are injected sequentially until a positive reaction develops or until the patient fails to react to the No. 1 dilution. If this happens, the patient has a negative reaction to that particular antigen.

The end point is the dilution that provides the first positive-reaction wheal, that is, a wheal that grows at least 2 mm greater than the preceding negative-reaction wheal and that also initiates wheals of progressively more positive reaction that are 2 mm or more on application of consecutively stronger Nos. 1 through 5 dilutions. The end point dilution designates at what dilution treatment may be started safely using an empirically designed mathematic formulas. Typically, a patient will not react with the same degree of sensitivity to each antigen. By testing for individual sensitivity to each antigen, therapy is much more efficient, since individuals with a weak degree of sensitivity can immediately be started at a high therapeutic dose and, conversely, those with severe sensitivity are treated with a lower dose. This time-honored and safe technique has been verified by the more sophisticated and recently developed in vitro techniques.

If the physician elects to do the diagnostic workup using in vitro methods, he or she will then use the IgE levels to design the plan of therapy, again using empiric formulas. Verification by skin testing is essential to assure that safety is maintained and the treatment antigens are effective.

The most common antigens causing inhalant allergies are pollens (which ones depend on the geographic area), animal danders, dust, and mold spores. Rural areas have, in addition, many other dusts and animal and plant by-products that can be extremely significant in controlling inhalant allergy.

If immunotherapy does not completely control the patient's symptomatology, and the history is indicative of food or chemical sensitivity, further diagnostic modalities must be used.

Food Allergy Diagnosis

Unfortunately, there are no efficient, quick methods of accurately diagnosing food allergy. Various studies reveal that there are different levels of IgE and IgG in relation to specific foods,

but unfortunately these levels do not correlate with the degree of reactivity nor do they have clinical significance. The only two diagnostic methods available to the office-based laryngologist are the provocative neutralization tests and individual deliberate feeding tests. The provocative neutralization test has a high degree of accuracy but is not particularly efficient, since each food must be tested separately, and each test may take as long as 30 to 40 minutes. The immunologic mechanisms of the provocative neutralization test are poorly understood, but double-blind studies have substantiated its efficacy. To perform this test, commercial extracts of various foods are serially diluted in the same manner as for inhalant antigens. No test is performed for any food that the patient is sure he or she is allergic to, and testing is usually confined to the hidden foods that appear repetitiously in the diet, such as milk, yeast, egg, corn, wheat, and soybean. The tests may be performed by intradermal injection, subcutaneous injection, or sublingual administration. The No. 1 dilution is administered to the patient, the skin is checked for wheal reaction, and the patient is observed for any objective findings or subjective symptoms. A saline placebo injection is used as a negative control. When symptoms are elicited by the injection, weaker injections are then used until symptoms have disappeared or, when symptoms are lacking, the wheal is judged to be negative. This dilution is then called the neutralizing dose.

To test foods that are easily eliminated from the diet, the patient is taught the individual deliberate feeding test. This test is usually performed by the patient at home, but the challenge can be done in the office for increased accuracy. This test is performed using the following steps in the order shown:

1. The test food should be eaten at least every 2 days for 2 weeks prior to elimination.

2. The test food should then be eliminated completely from the diet for 4 days.

3. On the fifth day, the test is performed 1 hour after the patient arises, unless symptoms are severe. On the test day, the patient should not smoke and should not take any unnecessary medications. Baseline symptoms are recorded.

4. Symptoms are looked for. If there is no reaction in 30 minutes, the patient should eat a smaller portion of the test food and watch for symptoms for 4 hours.

5. If the test food produces a positive reaction, symptoms may be acute and last up to 72 hours. If symptoms are especially uncomfortable, the patient may take a laxative or enema to hasten elimination.

6. A food causing a positive reaction should be eliminated for at least 6 months before rechallenging.

Finally, any food found to cause a positive reaction by provocative neutralization should also be tested by the challenge feeding test to assure that the provocative test was correct.

Chemical Allergy Diagnosis

If the clinical history points toward chemical sensitivities, provocative neutralization testing to basic chemicals is performed. Since there are literally thousands of chemicals in our modern society, this type of testing is admittedly very crude but can sometimes be very effective in helping the patient to work out the problems with the environment and avoid the development of new sensitivities. Chemical sensitivities may be encountered in the three major components of our environment: air, food, and water. This widespread contamination also tremendously complicates the accurate diagnosis of organic inhalant allergy and food sensitivity. Chemical testing is done by sublingual provocative neutralization to assure safety, and most clinicians test only for the common basic chemicals such as alcohol, phenol, formaldehyde, ethanol, chlorine, glycerine, petrochemical dyes, and tobacco smoke (Appendices D-G). Patients who become symptomatic in restaurants are also tested for monosodium glutamate, Aspartame, and sodium bisulfite. chemical sensitivity is particularly resistant to medical therapy, and patients must be taught to avoid common sources such as natural gas, particle board, cosmetics, aerosols, air fresheners, toxic fumes, synthetic clothing and bedding, and even the local water supply. Closed ventilation systems in modern buildings can spread a contaminant from a single source to all areas of the building. Allergy from chemical contamination of the workplace is particularly difficult to diagnose and often results in severe economic hardship. There is now evidence that many chemical sensitivities are mediated by IgE, and methods are being developed to demonstrate specific antibodies to specific chemicals, but these techniques are not yet available for general use.

Treatment

In planning a treatment protocol, the physician must always keep in mind the individuality of each patient. Cost factors, intelligence, financial status, motivation, and general health must all be considered when designing therapy for a specific patient. The fact that allergic disorders are dynamic and not constant must also be kept in mind. It is the duty of the physician not only to relieve the patient's symptoms but also to teach the patient to deal with the environment so that new allergies do not develop. A patient is usually not born with specific sensitivities but may inherit an allergic diathesis, and with proper education the development of new allergies can be prevented. The degree of severity of the patient's symptoms will also have a bearing on the treatment plan. If symptoms are slight and confined to the respiratory tract, pharmacologic treatment often suffices. Many patients will also demonstrate the allergic load phenomenon; that is, a combination of excitants of antigens will produce severe symptoms, whereas each antigen exposure individually produces little or no problem. Pharmacologic treatment is effective in inhalant allergy of the upper respiratory tract, but does little to control food or chemical sensitivities. This fact is demonstrated by the high recurrence and treatment failures found in conditions such as Ménière's disease, fluctuating tinnitus, nasal polyps, chronic headache syndromes, and systemic disorders such as arthritis, eczema, and ulcerative colitis.

Treatment of Inhalant Allergy

Pharmacologic Treatment of Inhalant Allergy

Antihistamines have been the mainstay of treatment of allergic rhinitis and sinusitis for many years. The allergic reaction breaks down mast cells and basophils, releasing histamine, which exerts potent effects on the cardiovascular system, smooth muscles, and exocrine glands. It produces capillary vasodilatation, increased permeability, edema, and smooth muscle contraction of the bronchi. It also causes increased secretion by nasal and bronchial glands, which is in most patients a very distressing symptom. Antihistamine drugs compete with the same cell receptor sites as histamine, thus therapy with these agents is termed a *competitive inhibition* process. The cell receptor sites are termed H_1 sites. Over the years, a multitude of different antihistamines has been brought on the market. The constant search for new forms of antihistamines results from the ineffectiveness or side effects of these drugs in most patients with inhalant allergies. Even when the drug is found to be effective, continued use often leads to tolerance and lack of symptom relief. Also, the patient must try many different products until one is found that is effective and has minimal side effects. In most patients, the most distressing side effect is sedation and drowsiness. Recently, three new antihistamines were brought on the market that do not cross the blood-brain barrier and therefore do not produce sedative side effects. Unfortunately, the symptom relief from these products is no better than with older drugs. Many complete lists of these medications and their wholesale prices can be found in various pharmaceutical publications and will not be listed here. It is best to attempt to identify more than one medication so that the patient can rotate two or three different antihistamines and avoid developing tolerance. The greatest advantage of long-term antihistamine therapy is its safety. Barring the development of true drug allergy, side effects, although distressing, are not seriously detrimental to the individual's overall health. Antihistamines also have other important uses, such as treatment of urticaria, anaphylaxis, angioedema, pruritus, and motion sickness. Some derivatives also have central nervous system effects that are helpful in treating psychologic disorders in Parkinson's disease.

Sympathomimetic drugs or decongestants cause vasoconstriction and elevated blood pressure and reduce edema in mucous membranes. Sympathomimetic agents are useful in various types of rhinitis, particularly when obstruction is present. They are most frequently administered in combination with antihistamines, anticholinergic agents, and expectorants, but they are also used singly, particularly in patients who cannot tolerate the side effects of antihistamines. The most common drugs in this category that are used in rhinitis include phenylephrine, phenylpropanolamine, ephedrine, pseudoephedrine, isoephedrine, and cyclopentamine.

Topical nasal decongestants in the form of drops or sprays have had widespread use and abuse for many years. They should never be used as a first line of therapy because of the fact that many patients demonstrate a rebound phenomenon that becomes worse with continued use until constant use of the drug is necessary to maintain any nasal potency. The patient, therefore, becomes addicted to the medication, resulting in the diagnosis of rhinitis medicamentosa. Topical decongestants are, however, particularly useful for emergency-type situations such as acute

sinusitis, aerotitis (barotitis media), inability to perform the Valsalva maneuver with resultant serous otitis, or tympanic membrane retraction and total nasal obstruction secondary to acute bacterial inflammation.

Cromolyn sodium is a highly effective drug that can now be found as a pulmonary inhaler, nasal inhaler, and an ophthalmic drop. It is administered topically and acts by stabilizing the mast cell, thereby preventing degranulation and release of histamine and the other mediators of allergic response. It is particularly effective when used in a protective manner in anticipation of heavy antigen exposure. Continuous use is effective and permissible if seasonal symptoms are short or if the patient fails to respond to immunotherapy. Another advantage to this drug, in addition to its effectiveness, is its safety; few, if any, serious side effects have been reported.

Systemic corticosteroids and adrenocorticotropic hormone (ACTH) are potent therapeutic agents and are rarely used as a first line of defense in the treatment of rhinitis because of their propensity to cause serious side effects. In healthy individuals who have only one seasonal pollinosis problem of short duration, a long-acting corticosteroid can be very effective provided that the patient has no other systemic diseases and is in good health. In acute exacerbations of inhalant food or chemical allergy short-acting steroids, in contrast to continuous therapy, are extremely valuable and safe when used properly. These short-acting drugs, which can be injected or ingested, can be used with antihistamines and antibiotics to treat acute infections in allergic patients. Injecting long-acting depo-type corticosteroids into the inferior turbinates enjoyed a brief span of popularity but is seldom used today because of severe possible side effects and poor long-term results. Many new topical aerosol corticosteroid preparations have recently been introduced to the marketplace with excellent response and few side effects in the treatment of rhinitis. These agents have been found to be helpful in the prevention of recurrent nasal polyposis and effective in controlling allergic rhinitis. In normal dosage, they have shown no evidence of causing adrenal suppression, in contrast to the systemic corticosteroids. Side effects include nasal irritation, dryness, crusting, and bleeding. Long-term therapy can result in sensitivity and side effects, and it is expensive. If continued use is necessary, these agents should be replaced by immunotherapy.

Immunotherapy of Inhalant Allergy

The development of accurate in vitro measurements of IgE- and IgG-blocking antibody has given us definite proof of the efficacy of properly administered immunotherapy. We know that allergy is a dynamic disease and in allergic patients, long-term symptomatology will be one of ups and downs of varying severity. If patients are repeatedly exposed to an antigen, chances of sensitivity are increased, and conversely avoidance of an antigen leads toward tolerance. Since avoidance of airborne antigens is extremely difficult, we are fortunate to have a methodology that controls inhalant allergy without any side effects. Research studies have demonstrated that effective immunotherapy lowers the level of IgE and increases the level of specific IgG, resulting in complete relief of symptoms for many patients. Continuation of therapy for 2 to 4 years may result in a complete lack of symptoms for many patients. Continuation of therapy for 2 to 4 years may result in a complete lack of symptoms without further therapy for a large majority of

patients. Immunotherapy can then result in a "cure" of the patient with inhalant allergy, and therein lies its tremendous advantage over pharmacologic treatment, which merely blocks the symptomatology. The key to effective immunotherapy is to find the optimum dose of antigen for each allergen and also to determine the interval of administration of this dose. For the past 40 years, otolaryngologists have based their therapy on skin end point titration, as standardized by Rinkel. The recent development of in vitro IgE measurement has proved both the efficacy of this system and that very few patients have the same degree of sensitivity for each antigen. Immunotherapy, therefore, can be started with a safe, but relatively potent, beginning dose for each allergen to be given, depending on its specific biologic sensitivity. This degree of sensitivity can be measured by skin end point titration or by specific IgE testing. Knowing this degree of sensitivity allows the physician to increase the potency of the allergen until a therapeutic response or maximum tolerated dose is achieved. The latter may be defined as that dose immediately preceding a nonacceptable local reaction or systemic symptom. Immunotherapy may be coseasonal or preseasonal. Coseasonal refers to that time of year when the patient is exposed to a sufficient amount of specific antigen to cause symptoms. This increased exposure may alter individual sensitivity; however, serial endpoint titration (SET) or in vitro techniques allow the patient to start therapy with a safe dose. It is important to remember that many patients' degree of sensitivity will change depending upon the time of year and the degree of exposure. If a patient with previously controlled allergy begins to show increased sensitivity in spite of continued immunotherapy, retesting and manipulation of dose strength may be necessary. Patients are advised that the ideal response to therapeutic injection is a small local reaction followed by a recognizable period of relief. This period of relief may vary, depending upon the length of time the patient has been under treatment or the season of the year when exposed. The strength of the dosage is increased either weekly or twice weekly until relief or the maximum tolerated dose is achieved. In general, the longer a patient is under treatment, the longer the interval between injections can be maintained.

The beginning student is advised to consult the classic series of articles in the Archives of Otolaryngology by Dr. Rinkel for details of SET testing and administration of immunotherapy. Many excellent texts and detailed courses in both skin testing and in vitro testing are available to the otolaryngologist for continued training, and an ever-increasing number of residency programs now include complete training in the management of otolaryngic allergy.

Treatment of Food Allergy

The treatment of food allergy must also include an appreciation of chemical sensitivity, since chemical-free or organically grown food is not prevalent in our modern society. In spite of this, however, if the diagnosis is correct and elimination of the offending foods is perfectly performed, *complete* control of food allergy should theoretically be possible. Elimination and rotary diet therapy are, therefore, the standard by which all other methods of treatment must be judged, both today and in the future. To advise patients properly requires a complete understanding of the complicated natural history of food allergy as well as being able to explain the importance of a rotary diet and the use of the challenge feeding test. The food- and chemical-sensitive patient must continually be reminded that repetitious exposure will lead to further

sensitivity and that safe foods must be rotated and the diet must be diversified. Patients must have a complete knowledge of the biologic classifications of foods by families and should be taught to try to obtain less chemically contaminated foods whenever possible. Education of the patient cannot be overemphasized. The rotary diet stresses individuals feedings of simple foods in large servings, with meals restricted to one to four foods, at intervals of 4 to 5 days. Ancillary personnel must be thoroughly educated in how to design a rotary diet for each individual. Although this type of eating pattern is totally foreign to almost all patients, it must be adhered to in severely food-allergic patients, or new sensitivities will surely develop. Patients must be taught that traditional nutrition and the usual four food groups are completely without scientific basis and as long as the patient has an adequate source of protein that he or she does not react to and eats a wide variety of fruits and vegetables, the nutritional status will be more than adequate and, in fact, superior to the usual American diet. In the properly diagnosed patient, therefore, the elimination rotary diversified diet becomes diagnostic, preventative, and therapeutic. Compliance with this type of program will depend upon the severity of symptoms, motivation, financial means, and the co-operation of the patient's family and friends. Physicians who hand the patient a series of elimination diets without educating him or her about the mechanisms of the problem will have poor long-term results. Many physicians have found that a group or class approach has a psychologic therapeutic benefit and is an effective time-saving method to achieve a successful education program.

In using the provocative neutralization tests, a neutralizing or symptom-relieving dose can be found for each specific food. This neutralizing dose can be used repeatedly as an active method of desensitization. To accurately determine the effectiveness of this type of treatment, it should be used only for those foods that the patient finds impossible to eliminate and should be limited to a maximum of five foods. The neutralizing doses can be administered through subcutaneous injections or by sublingual drops. Frequency of administration depends upon frequency of ingestion and individual response. In some patients, these techniques are not effective, and elimination of the offending food is the only effective method of treatment. There is no easy way out for the patient with multiple food allergies. If he or she does not continue with the rotary diversified diet and begins to eat safe foods repetitiously, new sensitivities will develop and further complicate the problem. If the properly educated patient adheres to the individual treatment protocol over time, he or she will become more and more tolerant to the environment and will be able to reintroduce foods that previously caused trouble. To be able to rehabilitate the individual with severe, chronic allergy, so that he or she can function again without physicians, medicines, or operations is indeed a most rewarding experience for any physician.

Treatment of Chemical Allergies

The philosophy of therapy for chemical sensitivity is to avoid triggering symptoms in the first place, rather than trying to counteract them with long-term medications once the reactions have taken place. As a result, the main methods of therapy include avoidance of offending substances, a rotation diet of chemically uncontaminated foods, and neutralization of adverse reactions by specific sublingual neutralizations or pharmaceutical drugs, or both.

Offending chemicals that cannot be tolerated, even infrequently, are eliminated from the patient's environment as much as possible. This may be a major undertaking but is often essential when other methods are not effective. This may require expensive alterations or complete abandonment of a patient's home and in severe cases may require career changes to attain a different working environment. Educating the patient as to the source of various chemicals in this environment is a never-ending process but is most important to successful treatment. It is important to explain to the patient the difference between toxicity and sensitivity. In the former, a high concentration of a specific chemical will cause reactions in all individuals, whereas only a small percentage of people will react severely to chemicals in weak dilutions. This sensitivity problem hinges on individual susceptibility and individual maladaptation to our modern environment. For example, extensive research has identified more than 120 chemicals that affect the sense of olfaction, even in extremely weak concentrations. Long-term studies have now proved that chronic exposure to many chemicals in concentrations formerly thought to be safe can result in significant increases of various types of malignancies. As previously stated, chemicals can be encountered as significant amounts in the three major components of our environment: air, food, and water. The patient must be taught to identify chemicals in each of these areas as well as how to eliminate them or reduce their concentration and to protect himself or herself from continued exposure.

When dealing with chemical inhalants, one must consider both the outdoor and indoor air. Outdoor air is the most difficult area to manage and many patients will have to change their residence from a chemical- or smoke-infected area to one in which the outdoor air is less contaminated with chemical substances. Patients must be advised to live for brief periods of time in all four seasons of the year in the proposed new location, since different excitants found in the new location may not allow a complete recovery. Indoor air pollution is usually a more common source of trouble for most chemically allergic patients and problems can be found in both the working place and the home. Formaldehyde is by far the most common indoor air pollutant and can be found in many building materials and home furnishings.

Chemicals play an ever-increasing role in contamination of our food supplies. Foods are contaminated in plating, fertilizing, growing, harvesting, preserving, distributing, and finally in preparation for eating. Commercial preparation in restaurants further adds to the problem by the use of things such as sodium monoglutamate, papain tenderizers, and metabisulfite.

Chemically treated water may also induce symptoms in susceptible patients. In the past, filtration and sterilization were all that was necessary to provide a safe water source; however, modern industrialization has added to our water many chemicals that do not break down naturally and can combine with chlorine and fluoride to produce even more toxic by-products. Chemical exposure in the workplace is an increasing problem and is extremely difficult to both diagnose and manage. In vitro methods that accurately identify specific chemical sensitivities are desperately needed so that these truly unfortunate individuals can be separated from psychosomatic and malingering patients. Acute exposure to an offending chemical can sometimes be neutralized by using the sublingual neutralizing dose that was found during testing. Some patients, when reacting, will respond to alkaline salts composed of two parts sodium bicarbonate

and one part potassium bicarbonate, the dosage being one teaspoon in half a glass of water, followed by two or more glasses of water. This treatment is not to be used in status asthmaticus, continued headache, or Ménière's disease. Salts should also be used with caution in patients with chronic cardiac and renal conditions. If an offending food or chemical is inadvertently ingested, plain milk of magnesia can be beneficial in hastening its removal from the body.

Discussion

Despite the controversy surrounding the importance of food and chemical allergy and the importance of immunotherapy for inhalants, the methods of diagnosis and treatment presented in this chapter are an established fact. No matter how effective surgery is for chronic rhinosinusitis, the disease will, without question, recur if the cause is not addressed. The sole reliance on pharmacologic methods to control symptoms becomes expensive and inefficient and leads to increasing severity of the diseased process. Because of the complexity and contamination of our environment, more and more patients are experiencing allergic problems. The modern otolaryngologist must at least be able to identify these conditions and if not able to diagnose and treat them properly, a knowledgeable modern otolaryngologic allergist must be consulted. Each physician should avail himself or herself of the references and many available instructional courses to learn in detail the methods of diagnosis and treatment. Education should be a never-ending process.

Appendix A: Rotary Diversified Diet Rules

The following ten rules have been developed by Dr. Theron Randolph and have been reprinted with his permission.

1. Any food in any amount or form must not be eaten more often than once in 4 days. When counting the days between foods, the next day following the last consumption of food is day 1.

Example: Apples eaten on Monday may not be eaten again until Friday, 4 days later.

2. Foods that are in the same family (related to one another) may be eaten in the following ways:

Food family members may be eaten together at the same meal and then rotated 4 days later.

Example: Monday breakfast: orange and grapefruit.
Friday breakfast: orange and grapefruit.

OR

Different foods in the same food family may be eaten on a rotation schedule alternating

them every 2 days (or every other day). Ideally, food family members should be separated by a minimum of 2 days and preferably 3 days.

Example: Monday breakfast: oranges.
Wednesday breakfast: grapefruit.
Friday breakfast: oranges.
Sunday breakfast: grapefruit.

As noted, the individual foods are separated by 4 days, and the family members are separated by 2 days.

3. Food family members may not be eaten at various times during a specific day. If you eat a food family member in the morning, you may not eat one of its family members during the same day.

Examples: Blueberries may be eaten at breakfast on a specific day, but cranberries (its food family member) may not be eaten for supper that same day. These two foods may be rotated alternately every 2 days or eaten together and rotated every 4 days.

4. When you pass a food in a specific family, you do not automatically pass other foods in that family. All foods must be tested, including food family members.

Example: If you pass carrot you may place it in your rotation diet. This does not automatically mean that celery, dill, parsnip, or parsley (its food family members) are safe to eat. You must test each of these foods before placing them in the diet.

5. More than one food in the same food family may be eaten at a single meal. Be sure that each of the foods are tested individually before putting them together.

Examples: Monday lunch: potato.
Wednesday lunch: tomato, green pepper, eggplant.
Friday lunch: potato.
Sunday lunch: tomato, green pepper, eggplant.
Tuesday breakfast: cantaloupe and honeydew melon.
Thursday lunch: zucchini and acorn squash.
Saturday breakfast: cantaloupe and honeydew melon.
Monday lunch: zucchini and acorn squash.

6. The specific time of day that the food is eaten is not essential, but remember to be faithful to the 4-day rotation.

Example: Strawberries that are eaten at breakfast on Wednesday may be eaten 4 days later at lunch on Sunday if desired.

7. All foods are to be eaten only once during a specific day and are not to be eaten throughout the day, even in small amounts.

Example: Milk consumed at breakfast may not be taken at lunch, supper, or any other time during that day. The next scheduled day for milk would be 4 days later.

8. Foods passed in one form may be automatically eaten in other forms at the same meal and then rotated 4 days later.

Examples: If you pass corn, you may also have corn sugar, corn oil, corn starch, corn meal, corn on the cob, popcorn, and so on, at a specific meal, and then rotate them all 4 days later. Milk may be eaten at one meal with its other forms such as butter, cream, cheese (if yeast is passed), sour cream, and then rotated 4 days later. Almonds may be eaten with almond oil or almond butter, or both. Buckwheat groats may be mixed or used with its other forms, including buckwheat four and oil.

9. All ingredients used in cooking must be regarded as separate foods, including oils, spices, and flavoring and must be tested and then rotated on a 4-day or longer rotation schedule.

10. Think innovatively in preparing your rotary diversified diet. If you have only one food per meal, be creative and try the following suggestions:

Eat the food raw, steamed, and cooked whenever possible. This gives different textures and flavors to the food.

Example: Have carrots raw, steam some, and perhaps have some shredded with a little carrot juice added.

Use the juices of the specific food whenever possible, as there are numerous vegetable and fruit juices available.

Example: Tomato juice may be used cold for a beverage or heated up with stewed tomatoes to make a hot steeping bowl of soup, or it may be ingested both ways.

Freezing fruits and eating them partially frozen can be a real change as well as an enjoyable treat. Some fruits may be frozen, pureed in a blender, and served as an ice cream.

Example: Bananas may be frozen in their peel and placed in a freezing container. When frozen, place the banana (without peel) in a blender for a short time and then place in serving bowls for a mock banana ice cream.

Dried foods may also add texture and variation to your diet, so use whenever possible.

Example: Fresh pineapple, dried pineapple, and pineapple juice may be eaten together at

one meal.

Appendix B: Food Allergy - Nutritional Questionnaire

Name _____ Date _____

Please read each question carefully.

Then circle Yes or No to indicate your answer. If yes, please explain.

Yes No 1. Are there any foods or beverages that you (a) crave or (b) eat frequently? List:
(a) _____ (b) _____
_____ _____
_____ _____
_____ _____

Yes No 2. Are there any foods or beverages that you dislike? List:
_____
_____
_____
_____

Yes No 3. Are you awakened between the hours of 1:00 am and 5:00 am with the following symptoms: headache, dizziness, stomach cramps, bloating, or dry cough? (Circle which.)

Yes No 4. Do you or any members of your family have hay fever, asthma, hives, chronic skin condition, migraine headaches, or colitis? (Circle which.)

Yes No 5. During childhood did you have any of the following: eczema, hay fever, asthma, food feeding problems? (Circle which.)

Yes No 6. Do you ever have itching of the skin, palate, or roof of your mouth or skin rash? (Circle which.)

Yes No 7. Do you frequently notice swelling of your ankles, feet, hands, or face? (Circle which.)

Yes No 8. Do you have marked fatigue 2 to 3 hours after meals?

Yes No 9. Do you eat snacks frequently between meals? List examples.
_____
_____

_____

_____

Yes No 10. Do you have excessive chilling when a sudden change in temperature occurs?

Yes No 11. Do you have frequent headaches or "migraine"?

Yes No 12. Do you experience belching, abdominal distention, bloating, or cramps following meals?

Yes No 13. Have you noticed numbness of the face, arms, or legs at periodic intervals for no apparent cause?

Yes No 14. Do you have drowsiness, headache, or bloating following the ingestion of a cocktail, glass of beer, or glass of wine? (Circle which.)

Yes No 15. Do you have alternating constipation and diarrhea?

Yes No 16. Do you have joint or muscle pain or stiffness?

Yes No 18. Do you have recurring fungal infections (vaginitis, athlete's foot, jock itch, or ring worm)?

Appendix C: Chemical Allergy Questionnaire

Name _____ Date _____

Yes No 1. Do you dislike the taste of your tap water or do you feel that it causes symptoms?

Yes No 2. Do you react to woodburning stoves, fireplaces, or kerosene space heaters?

Yes No 3. Do you react when entering fabric shops, carpet stores, grocery stores, or department stores?

Yes No 4. Do you react to or dislike the odor of perfume, soap, detergents, colognes, or other solvents, such as fingernail polish remover, pain remover, model airplane glue, and so on?

Yes No 5. Do you dislike or react to disinfectants, insecticides, sprays, ammonia, or moth balls?

Yes No 6. Do you react to or dislike to odor of Christmas trees or other indoor

evergreen decorations, odor from sanding or woodworking, odor of a cedar closet, or pine-scented household deodorants, shampoos, or turpentine-based paints?

Yes No 7. Do you react to or dislike the odor of exhaust fumes, jet airplane exhausts, oil, or gas fumes or diesel fumes from trucks and buses?

Yes No 8. Do you feel that you react to your working environment, either continuously or depending upon the area of the workplace that you are in?

Yes No 9. Do you have hobbies that involve exposure to smells, odors, chemicals, paints, ceramics, or dusty, moldy, chemically contaminated areas?

Yes No 10. Do you have a tendency to have unpleasant feelings or reactions to all medicines taken by mouth regardless of what condition they are given for?

Yes No 11. Do you take large amounts of over-the-counter medications, such as vitamins, headache pills, sinus pills, and so on?

Yes No 12. Do you react to other people's use of tobacco (cigarettes, pipes, cigars)?

Yes No 13. Do you react to all types of fresh fruit and vegetables and improve if the substances are cooked or peeled?

Yes No 14. Do you react to foods that are commercially prepared while not reacting to the same foods that are eaten fresh or prepared at home?

Yes No 15. Do you have difficulty eating in restaurants, but are able to eat the same foods when prepared at home?

Yes No 16. Do you feel that you perform or feel better in natural lighting compared with fluorescent lighting?

Yes No 17. Do you react to newsprint or other printed material?

Appendix D: Alcohol

Alcohol is the class name for a group of chemicals recognized as having a certain definite chemical makeup; it contains one or more carbinol groups. This is written C-O-H. H is a hydrogen atom attached to an oxygen atom, which is also attached to a carbon atom. This carbon atom has at least three other attachments. These formulas then result in methyl alcohol (also called methanol or wood alcohol), amyl alcohol, isopropyl alcohol, butyl alcohol, ethylene glycol (which is used as permanent antifreeze), glycerine or glycerol, and menthol.

1. Ethyl alcohol:

- Formed as wine or hard cider by the fermentation of any sweet fruit juice. Industrial ethyl alcohol may be made from molasses, potatoes, or grain - particularly corn.
- Will dissolve many organic substances such as shellac and oil.
- An ingredient in tinctures and many toilet and drug preparations.
- Used as body rubbing alcohol.
- Used in making ether and sterilizing surgical instruments.
- Used in making rubber.

2. Amyl alcohol:

- Made from ethyl alcohol.
- Used as solvent.

3. Isopropyl:

- Used in manufacture of alcohol, antifreeze, rubbing alcohol, and solvents.

4. Glycerol:

- Used for sweetening and preserving food.
- Used in the manufacture of cosmetics, perfumes, inks, and certain glues and cements.
- Used in medicine in suppositories and skin emollients.

5. Menthol:

- Used in perfumes, confections, liqueurs.
- Used in medicine for colds and nasal disorders because of its cooling effect on mucous membranes.

Products of Alcohol

1. Anesthetic.
2. Cleaning fluid.
3. Flavoring extract.

Direct uses of Alcohol

1. Source of light and heat.
2. Motor fuel.
3. Disinfectant.
4. Sedative.
5. Preservative.
6. Acetic acid.
7. Explosives.
8. Formaldehyde plastics.
9. Rubber tires (buna).
10. Rubber overshoes (butadiene).
11. Synthetic chemicals.

Alcohol is used in the Preparation of

1. Hand lotions.
2. Perfumes.
3. Celluloid, toothbrushes, Bakelite products.
4. Dyes.
5. Drugs.

6. Photographic film.

7. Paint and varnish.

8. Rayon textiles.

9. Nylon textiles.

10. Soaps.

11. Printer's ink.

Appendix E: Ethanol

Ethanol is made from ethylene gas by oil companies and is used widely in oil products. Ethanol is also made from grain. It is used to produce the following:

Shellac
Oil
Rubbing alcohol
Ether
Rubber
Perfumes
Deodorant
Soaps
Detergents
Shampoo
Aftershave lotion
Mothballs
Hair spray
Insect spray
Asphalt
Paint
Varnish
Glue
Gasoline
Exhaust fumes
Crude petroleum and its derivatives.

Appendix F: Formaldehyde

Formaldehyde is the first member of the aldehyde group RCOH, where R=H. Other common names include formalin and methanal. Formaldehyde is obtainable in gaseous or liquid form.

Uses of Formaldehyde

1. Intermediates in the synthesis of alcohols, acids, and other chemicals.

2. Tanning agent.

3. Used in the formulation of slow-release nitrogen fertilizers and in destroying microorganisms responsible for plant diseases

4. Used as additional agent to make concrete, plaster, and related products impermeable to liquids

5. An antiperspirant and an antiseptic in dentifrices, mouthwashes, and germicidal and detergent soaps; also used in hair setting and in shampoos.

6. Air deodorant in public places and in industrial environments.

7. Destroys bacteria, fungi, molds, and yeasts. Disinfects equipment in fermentation industry and in manufacture of antibiotics; disinfects sickrooms and surgical instruments.

8. Synthesis of dyes, stripping agents, and various specialty chemicals in the dye industry; also improves the color stability of dyed fabrics.

9. Used in combination with alcohol, glycerol, and phenol in embalming fluids; is also used to preserve products such as waxes, polishes, adhesives, fats, oils, and anatomic specimens.

10. Synthesis of explosives.

11. Used in conjunction with other chemicals in preparing fireproofing compositions to apply to fabrics.

12. Used in insecticidal solutions for killing flies, mosquitoes, and moths; also used as a rodent poison.

13. Used in the synthesis of vitamin A and in improving the activity of vitamin E preparations.

14. Improves the wet strength and water resistance of paper products.

15. Preservative and accelerator for photographic developing solutions.

16. Used to make natural and synthetic fibers crease-resistant, wrinkle-resistant, crushproof, water-repellant, dye-fast, flame-resistant, water-resistant, shrink-proof, mothproof (wool), and more elastic (wool).

17. Used in making synthetic resins, wood veneer (for wall paper), and artificial aging, reduction of shrinkage in wood preservation.

18. One of the component parts of wallboard used in construction of houses and apartments

19. Used as resin in nail polish and undercoating of nail polish.

Formaldehyde usually accounts for about 50 per cent of the estimated total aldehydes in polluted air. The major sources of aldehyde pollution are in the incomplete combustion of hydrocarbons in gasoline and diesel engines, burning of fuels, and incineration of waste. Formaldehyde is believed to be the principal agent responsible for the burning of eyes in smog. Aldehydes can also react further to form additional products such as more ozone.

Nationwide spot checks show the following ambient air sources of aldehydes:

Formaldehyde-producing plants	2580 ppm
Gasoline automobiles	50-100 malfunctioning
Combustion of coal	0.06-0.25
Fuel oil combustion	3-52
Natural gas combustion	5-15
Incinerator	40
Small domestic incinerators	1-67
Backyard incinerators	760
Petroleum refineries	3-130
Drying ovens	52
Small-batch auto incinerators	16
Aircraft	5 (idling) 1 (takeoff)
Baking of lithographic coatings	12-186.

Appendix G: Phenol

Phenol is any of a family of organic compounds characterized by attachment of at least one hydroxyl group to a carbon atom forming part of the benzene ring.

Phenol is also called carbolic acid of hydroxybenzene. In 1834, a German named Runge isolated carbolic acid from coal tar. In 1843, another German, Gerhardt, prepared the same substance by a different method and called it phenol.

In 1845, an English surgeon, Joseph Lister, began to use a dilute solution of phenol to treat wounds, establishing its use as an antiseptic.

Phenol is used in the production of the following:

Acne medications
Baking powder
Caulking agents
Disinfectants
Enamel paint
Fiberglass
Flame retardant finishes
Food additives
Inks (fountain pen, printers)
Insulation (thermal and acoustical)
Jute or hemp fiber preservative - (carpet backing, area rugs, rope, twine)
Laundry starches
Matches
Mildew proofing
Plastics
Preservatives in hair care products
Sealants
Shaving creams and lotions
Shoe polishes
Soundproofing
Solvent
Spandex (girdles, support hose, and so on)
Stamp pads
Tin can inner linings
Watercolor paints
Wood preservatives.

Other uses of phenol follow:

1. Serves as a starting point for production of epoxy and phenolic resins, aspirin, and other drugs).

2. Used in manufacture of picric acid explosives.

3. Constituents of herbicides and pesticides.

4. Phenolic resin (Bakelite) formed by reaction of phenol (C_6H_5OH) with formaldehyde (CH_2O) and used in molded articles such as telephone parts, thermal insulation panels, and laminated boards, children's toys, refrigerator storage dishes, and so on.

5. Used in manufacture of nylon.

6. Used in manufacture of polyurethane.

7. Used in manufacture of synthetic detergents.

8. Used in manufacture of perfume.

9. Used in manufacture of gasoline additives.

10. Used in manufacture of dyes.

11. Used in manufacture of photography solutions.

12. Preservative in medications; preservative for antigen serum in allergy shots.

There are naturally occurring phenols:

1. The toxic agent in poison ivy and poison oak.

2. Thyme oil from thyme is used as an intermediate solution in production of menthol.

3. May occur in spring water as a result of humus in or around spring or from natural coal around spring.