

Chapter 109: The Professional Voice

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The subtle complexities of an exacting demands on professional voice users create an exciting challenge and special responsibility for the otolaryngologist-head and neck surgeon. Professional voice users include not only singers but also politicians, attorneys, members of the clergy, educators (including some physicians), and telephone operators. They encompass a broad range of vocal sophistication and voice needs, but they share dependence on vocal endurance and quality for their livelihood. Professional singers are discussed at length in this chapter because they have the greatest vocal demands and require the most sophisticated analysis. Mastery of the science and art of caring for singers generally provides the physician with sufficient expertise to treat other professional voice users (Sataloff, 1991).

Most people appreciate singers' talent, but very few understand their craft. Although physicians frequently are called on to care for professional singers with voice difficulties, most have little or no training in sophisticated analysis and treatment of subtle problems of the voice. Most successful singers work and study for years to master their art. Some of them earn hundreds of thousands of dollars with their voices. Consequently, physicians are faced with the challenge, responsibility, and liability of providing accurate diagnoses and treatment. This may be accomplished through thorough, systematic inquiry and analysis based on understanding of the anatomy, physiology, psychology, and psychoacoustics of voice production. Hypochondriasis is uncommon among serious singers. In general, failure to establish a diagnosis of a professional singer with a voice complaint is a result of lack of physician expertise rather than an "imaginary" complaint.

Anatomy

The anatomy of a singer is not limited to the region between the suprasternal notch and the hyoid bone. Practically all body systems affect the voice. The larynx receives the greatest attention because it is the most sensitive and expressive component of the vocal mechanism, but anatomic interactions throughout the patient's body must be considered in treating the professional voice.

Larynx

A detailed discussion of laryngeal anatomy is beyond the scope of this chapter. However, it is helpful to think of the larynx as composed of four anatomic units: mucosa, skeleton, intrinsic muscles, and extrinsic muscles. The vibratory margin of the vocal fold is much more complicated than mucosa applied to muscle. This structure consists of five layers (Hirano, 1977) (Fig. 109-1). This thin, lubricated squamous epithelium covering the vocal folds forms the area of contact between the vibrating vocal cords and acts somewhat like a capsule, helping to maintain vocal cords and acts somewhat like a capsule, helping to maintain vocal fold shape. The superficial layer of the lamina propria, also known as Reinke's space, is made up of loose fibrous components and matrix. It contains very few fibroblasts. The intermediate layer of the lamina propria contains more fibroblasts and consists primarily of elastic fibers. The deep layer of the lamina propria is composed primarily of collagenous fibers and is rich in fibroblasts. The vocalis muscle makes up the body of the vocal fold and

is one of the intrinsic laryngeal muscles. The region of the intermediate and deep layers of the lamina propria is called the vocal ligament; it lies immediately below Reinke's space.

Functionally, the various layers have different mechanical properties and act somewhat like ball bearings of different sizes in allowing the smooth shearing action necessary to proper vocal fold vibration. Mechanically, they actually act more like three layers consisting of the cover (epithelium and Reinke's space), transition (intermediate and deep layers of the lamina propria), and body (the vocalis muscle). Understanding this anatomy is important because different pathologic entities occur in different layers. Moreover, fibroblasts are responsible for scar formation. Therefore, lesions that occur in the cover (such as nodules, cysts, and most polyps) should permit treatment without disturbance of the intermediate and deep layers, fibroblast proliferation, or scar formation.

Intrinsic muscles are responsible for abduction, adduction, and longitudinal tension of the vocal folds. Extrinsic laryngeal musculature maintains the position of the larynx in the neck. Because raising or lowering the larynx may alter the tension or angle between laryngeal cartilages, the extrinsic muscles are critical in maintaining a stable laryngeal skeleton so that the delicate intrinsic musculature can work effectively. In the trained singer, the extrinsic muscles maintain the larynx in a relatively constant position. Training of the intrinsic musculature results in vibratory symmetry of the vocal folds, producing regular periodicity. This contributes to what the listener perceives as a "trained" voice. The vocal folds may be thought of as the oscillator of the vocal mechanism (Sundberg, 1977).

Supraglottic vocal tract

The supraglottic larynx, tongue, lips, palate, pharynx, nasal cavity, and possibly the sinuses shape the sound quality produced at the level of the vocal cords by acting as a resonator. Minor alterations in the configuration of these structures may produce substantial changes in voice quality. The hypernasal speech typically associated with a cleft palate or the hyponasal speech characteristic of severe adenoid hypertrophy is obvious. However, mild edema from an upper respiratory tract infection, pharyngeal scarring, or muscle tension changes produce less obvious sound alterations. These are immediately recognizable to a trained vocalist or astute critic but often elude the laryngologist.

Tracheobronchial tree, lungs, and thorax

In singing, the lungs supply a constant stream of air that passes between the vocal folds and provides power for voice production. Singers often are thought of as having "big chests". Actually, the primary respiratory difference between trained and untrained singers is not increased total lung capacity, as popularly assumed; rather, the trained singer learns to use a higher proportion of the air in the lungs, thereby decreasing residual volume and increasing respiratory efficiency (Gould and Okamura, 1973).

Abdomen

The abdominal musculature is the so-called support of the singing voice, although singers generally refer to the "diaphragm" as the support mechanism. The diaphragm generates inspiratory forces. Although the abdomen can perform this function in some

situations (Hixon and Hoffman, 1978), it is primarily an expiratory-force generator. The abdominal musculature receives considerable attention in vocal training. The purpose of abdominal support is to maintain an efficient, constant power source and inspiratory-expiratory mechanism. Voice teachers disagree as to the best model for teaching support technique. Some experts describe positioning the abdominal musculature under the rib cage; others advocate distension of the abdomen. Either method may result in vocal problems if used incorrectly, but distending the abdomen (the inverse pressure theory) is especially dangerous because it tends to focus the singer's muscular effort in a downward and outward direction, which is ineffective. Thus, the singer may exert considerable effort, believing he or she is practicing good support technique, without obtaining the desired effect. Proper abdominal training is essential to good singing, and the physician must consider abdominal function when evaluating vocal disabilities.

Musculoskeletal system

Musculoskeletal condition and position affect the vocal mechanism and may produce tension or impair abdominal muscle function, causing voice dysfunction. Stance deviation, such as the difference between standing and the supine position, produces obvious changes in respiratory function. However, lesser changes, such as distributing one's weight over the calcaneus rather than forward over the metatarsal heads (a more athletic position), alter the configuration of the abdominal and back musculature enough to influence the voice. Tensing arm and shoulder muscles promotes cervical muscle strain, which can adversely affect the larynx. Careful control of muscle tension is fundamental to good vocal technique. In fact, some methods use musculoskeletal conditioning as the primary focus of voice training.

Psychoneurologic system

The psychoneurologic constitution of the singer has a direct impact on the vocal mechanism. Psychologic phenomena are reflected through the autonomic nervous system, which controls mucosal secretions and other functions critical to voice production. The nervous system is also important for its medication of fine muscle control. This fact is worthy of emphasis because minimal voice disturbances may occasionally be the first signs of serious neurologic disease.

Patient History

Extensive historical background is necessary for thorough evaluation of the singing voice, and the otolaryngologist who sees singers only on occasion cannot reasonably be expected to remember all the pertinent questions. Although some laryngologists consider a lengthy inquisition helpful in establishing rapport with professional singers, many of use who see a substantial number of singers per day within a busy practice need a thorough but less time-consuming alternative. A history questionnaire for professional singers can be extremely helpful in documenting all the necessary information, in helping the singer sort out and articulate his or her problems, and in saving the clinician time recording information. During the last few years, I have developed a questionnaire (Sataloff, 1984, 1991) that has proved helpful (see box). The singer is asked to complete the form in the waiting room before seeing the doctor.

No history questionnaire is a substitute for direct, penetrating questioning by the physician. However, the direction of most useful inquiry can be determined from a glance at the questionnaire. Obviating the need for extensive writing permits the physician greater eye contact with the patient and facilitates rapid establishment of the close rapport and confidence that are important in treating professional singers. The physician is also able to supplement initial impressions and historical information from the questionnaire with seemingly leisurely conversation during the physical examination. The use of the historical questionnaire has added substantially to the efficiency, consistent thoroughness, and ease of managing these delightful, but often complex patients.

Age

Serious vocal endeavour may start in childhood and continue throughout a lifetime. As the vocal mechanism undergoes normal maturation, the voice changes. The optimal time to begin serious vocal training is controversial. For many years, most people advocated delay of vocal training and serious singing until near puberty in the female and after puberty and voice stabilization in the male. However, in a child with earnest vocal aspirations and potential, starting specialized training early in childhood is reasonable. Initial instruction should teach the child to vocalize without strain and avoid all forms of voice abuse. It should not permit premature indulgence in operatic bravado. Most experts agree that singing during puberty should be minimized or avoided altogether, particularly by the male. Recent studies indicating the contrary are controversial. Voice maturation may occur at any age from the early teenage period to the fourth decade of life. The dangerous tendency for young singers to attempt to sound older than their vocal years frequently causes vocal dysfunction.

All components of voice production are subject to normal aging. Abdominal and general muscular tone frequently decrease, lungs lose elasticity, the thorax loses its distensibility, the mucosa of the vocal tract atrophies, mucous secretions change character, nerve endings are reduced in number, and psychoneurologic functions change. Moreover, the larynx itself loses muscle tone and bulk and may show depletion of submucosal ground substance in the vocal folds. The laryngeal cartilages ossify and the joints may become arthritic and stiff. The hormonal environment is altered. Vocal range, intensity, and quality all may be modified. Vocal fold atrophy may be the most striking alteration. The clinical effects of aging seem more pronounced in female singers, although vocal fold histologic changes may be more prominent in males. Excellent male singers occasionally extend their careers into their seventies or beyond (von Leden, 1977; Ackerman and Pfan, 1974). However, some degree of breathiness, decreased range, and other evidence of aging should be expected in elderly voice.

Complaint

Careful questioning as to the onset of vocal problems is needed to separate acute from chronic dysfunction. Often an upper respiratory tract infection will send a singer to the physician's office, but penetrating inquiry may reveal a chronic vocal problem that is the singer's real concern. Identifying acute and chronic problems before beginning therapy is important so that both patient and physician may have realistic expectations and optimal therapeutic selection.

The specific nature of the vocal complaint can provide a great deal of information. Just as dizzy patients rarely walk into the physician's office complaining of "rotary vertigo", singers may be unable to articulate their symptoms without guidance. They may use the term *hoarseness* to describe a variety of conditions that the physician must separate. Hoarseness is a coarse or scratchy sound most often associated with abnormalities of the leading edge of the vocal folds such as laryngitis or mass lesions. Breathiness is a vocal quality characterized by excessive loss of air during vocalization. In some cases, it is due to improper technique. However, any condition that prevents full approximation of the vocal folds can be responsible. Such causes include vocal fold paralysis, a mass lesion separating the leading edges of the vocal folds, arthritis of the cricoarytenoid joint, arytenoid dislocation, unilateral scarring of the vibratory margin, and senile vocal cord atrophy.

Fatigue of the voice is inability to continue to sing for extended periods without change in vocal quality. The voice may signal fatigue by becoming hoarse, losing range, changing timbre, breaking into different registers, or exhibiting other uncontrolled aberrations. A well-trained singer should be able to sing for several hours without vocal fatigue. Fatigue is often caused by misuse of abdominal and neck musculature or "oversinging", singing too loudly too long. Vocal fatigue may be a sign of general tiredness or serious illnesses such as myasthenia gravis.

Volume disturbance may manifest itself as inability to sing loudly or inability to sing softly. Each voice has its own dynamic range. Within the course of training, singers learn to sing more loudly by singing more efficiently. They also learn to sing softly, a more difficult task, through years of laborious practice. Most volume problems are secondary to intrinsic limitations of the voice or technical errors in singing, although hormonal changes, aging, and neurologic disease are other causes. Superior laryngeal nerve paralysis impairs the ability to sing loudly. This is a frequently unrecognized consequence of herpes infection (such as "cold sores") (Adour, 1983) and may be precipitated by an upper respiratory tract infection.

Most singers require only about 10 minutes to half an hour to "warm up the voice". *Prolonged warm-up time*, especially in the morning, is most often caused by reflux laryngitis. *Tickling* or *choking* during singing is associated with laryngitis or voice abuse. Often a symptom of abnormality of the vocal fold's leading edge, tickling or choking should contraindicate singing until vocal cord examination. *Pain* while singing can indicate vocal cord lesions, laryngeal joint arthritis, infection, or gastric acid irritation of the arytenoids. However, pain is much more commonly caused by voice abuse with excessive muscular activity in the neck rather than acute abnormality on the leading edge of a vocal fold. These patients do not require immediate cessation of singing pending medical examination.

Date of the next important performance

If a singer seeks treatment at the end of the busy season and has no pressing engagements, management of the voice problem should be relatively conservative and designed to assure long-term protection of the larynx, the most delicate part of the vocal mechanism. However, the physician and patient rarely have this luxury. Most often, the singer needs treatment within a week of an important engagement, and sometimes within less than a day. Younger singers fall ill shortly before performances, not because of hypochondria or coincidence but rather because of the immense physical and emotional stress of the

preperformance period. The singer is frequently working harder and singing longer hours than usual. Moreover, he or she may be under particular pressure to learn new material and to perform well for a new audience. Furthermore, the singer may be sleeping less than usual because of additional time rehearsing or because of the discomforts of a strange city. Seasoned professionals make their living by performing regularly, sometimes several times a week. Consequently, *any* time they get sick is likely to precede a performance. Caring for voice complaints in these situations requires highly skilled judgment and bold management.

Professional singing status and goals

To choose a treatment program, the physician must understand the importance of the singer's voice in his or her long-term career plans, the importance of the upcoming concert, and the consequences of cancelling the concert. Injudicious prescription of voice rest can be almost as damaging to a vocal career as ill-advised performance. Although a singer's voice is his or her most important commodity, other factors distinguish the few successful artists from the multitude of less successful singers with equally good voices. These include musicianship, reliability, and "professionalism". Cancelling a concert at the last minute may seriously damage a performer's reputation. Reliability is especially critical early in a singer's career. Moreover, an expert singer often can modify a performance to decrease the strain on his or her voice. No singer should be allowed to perform in a manner that will permit serious injury to the vocal folds, but in the frequent borderline cases, the condition of the larynx must be weighed against other factors affecting the singer as an artist.

Amount and nature of vocal training

Establishing how long a singer has been singing seriously is important, especially if his or her active performance career predates the beginning of vocal training. Active amateur singers frequently develop undesirable techniques that are difficult to modify. Extensive voice use without training or premature training with inappropriate repertoire may underlie persistent vocal difficulties later in life. The number of years a singer has been training his or her voice may be a fair index of vocal proficiency. A person who has studied voice for 1 or 2 years is somewhat more likely to have gross technical difficulties than is someone who has been studying for 20 years. However, if training has been intermittent or discontinued for some time, technical problems are common. In addition, methods vary among voice teachers. Hence, a student who has had many teachers commonly has numerous technical insecurities or deficiencies responsible for vocal dysfunction. This is especially true if the singer has changed to a new teacher within the preceding year. The physician must be careful not to criticize the patient's current voice teacher in such circumstances. It often takes years of expert instruction to correct bad habits.

All people speak more often than they sing, yet most singers report little speech instruction. Even if a singer uses the voice flawlessly while practicing and performing, voice abuse at other times can cause damage that affects singing.

Type of singing and environment

The *Lombard effect* is the tendency to increase vocal intensity in response to increased background noise. A well-trained singer learns to compensate for this tendency and to avoid singing at unsafe volumes. Singers of classical music usually have such training and frequently perform with only a piano, a situation in which the balance can be controlled well. However, singers performing in large halls, with orchestras, or in operas early in their careers tend to oversing and strain the voice. Similar problems occur during outdoor concerts because of the lack of auditory feedback. This phenomenon is seen even more among "pop" singers. Pop singers are in a uniquely difficult position; often despite little vocal training they enjoy great artistic and financial success and endure extremely stressful demands on their time and voice. They are required to sing in large halls not designed for musical performance, amid smoke and other environmental irritants, accompanied by extremely loud background music. One frequently neglected key to survival for these singers is the proper use of monitor speakers. These direct the sound of the singer's voice toward the singer on the stage and provide acoustic feedback. In addition to the usual investigation, determining whether the pop singer uses monitor speakers and whether they are loud enough for the singer to hear is important.

Amateur singers are often no less serious about their music than are professionals, but generally they have less ability to compensate technically for handicaps produced by illness or other physical disability. Rarely does an amateur suffer a great loss from postponing a performance or permitting someone to sing in his or her place. In most cases, the amateur singer's best interest is served through conservative management directed at long-term maintenance of good vocal health. A great many singers who seek physician's advice are primarily choral singers. They often are enthusiastic amateurs, untrained but dedicated to their musical recreation. They should be handled as amateur solo singers, educated specifically about the Lombard effect, and cautioned to avoid the excessive volume so common in a choral environment. One good way for a singer to monitor loudness is to cup a hand to the ear. This adds about 6 dB (Schiff, 1978) to the singer's perception of his or her own voice and can be a very helpful guide in noisy surroundings.

Young professional singers are often hired to augment amateur choruses. Feeling that the professional quartet has been hired to "lead" the rest of the choir, they often make the mistake of trying to accomplish the goal by singing *louder* than others in their section. Such singers should be advised to lead their section by singing each line as if they were soloists giving a voice lesson to the two people standing beside them and as if there were a microphone in front of them recording the performance for the voice teacher. This approach usually not only preserves the voice but produces a better choral sound.

Rehearsal

Vocal practice is as essential to the singer as exercise is to the athlete. Proper vocal practice incorporates scales and specific exercises designed to maintain and develop the vocal apparatus. Simply singing songs and giving performances without routine studious concentration on vocal technique is not adequate for the performing singer. The physician should know whether the singer practices daily, whether he practices at the same time daily, and how long the practice lasts. Most serious singers practice for at least 1 to 2 hours per day.

If a singer routinely practices in the late afternoon or evening but frequently performs in the morning (religious services, school classes, teaching voice, choir rehearsals, etc), one should inquire into the warm-up procedures preceding such performances. Singing "cold", especially at unaccustomed hours of the morning, may result in the use of minor muscular alterations to compensate for vocal insecurity produced by inadequate preparation. Such crutches can result in voice dysfunction. Similar problems may result from instances of voice use other than formal singing. Schoolteachers, telephone receptionists, sales people, and others who speak extensively often derive great benefit from 5 or 10 minutes of vocalization of scales first thing in the morning. Although singers rarely practice the scales too long, they frequently perform or rehearse excessively. This is especially true immediately before a major concert or audition, when physicians are most likely to see acute problems. When a singer has hoarseness and vocal fatigue and has been practicing a new role for 14 hours a day for the last 3 weeks, no simple prescription will solve the problem. However, a treatment regimen can usually be designed to carry the performer safely through his or her musical obligations.

Voice abuse in singing

A detailed discussion of vocal technique in singing is beyond the scope of this chapter. However, the most common technical errors involve excessive muscle tension in the tongue, neck, and larynx; inadequate abdominal support; and excessive volume. Inadequate preparation can be a devastating source of voice abuse and may result from limited practice, limited rehearsal of a difficult piece, or limited vocal training for a given role. The latter error is tragically common. In many situations, voice teachers are at fault, especially in competitive academic environments. Both singer and teacher must resist the impulse to show off the voice in works that are either too difficult for the singer's level of training or simply not suited to the singer's voice. Singers are habitually unhappy with the limitations of their voices. At some time or another most baritones wish they were tenors and walk around proving they can sing high C's in "Vesti la Giubba". Singers with other vocal ranges have similar fantasies. Attempts to make the voice something that it is not, or at least that it is not yet, are frequently harmful.

Voice abuse in speaking

Dissociation of one's speaking and singing voices is probably the most common cause of voice abuse problems in excellent singers. Too frequently, all the expert training in support, muscular control, and projection is not applied to a singer's speaking voice. Unfortunately, the resultant voice strain affects the singing voice as well as the speaking voice. Such damage is especially likely to occur in noisy rooms and in cars, where the background noise is louder than it seems. Backstage greetings after a lengthy performance can be particularly devastating: The singer usually is exhausted and distracted; the environment is often dusty and dry, and generally a noisy crowd is present. Similar conditions prevail at postperformance parties, where smoking and alcohol worsen matters. These situations should be avoided by any singer with vocal problems and should be controlled through awareness at other times.

Three particularly destructive vocal activities are worthy of note. Cheerleading requires extensive screaming under the worst possible physical and environmental circumstances. It is a highly undesirable activity for anyone considering serious vocal endeavour. This is a common conflict in younger singers because the teenager who is the high school choir soloist

often is also student council president, yearbook editor, captain of the cheerleaders, and so on. Conducting, particularly choral conducting, can also be deleterious. An enthusiastic conductor, especially of an amateur group, frequently sings all four parts intermittently, at volumes louder than the entire choir, for lengthy rehearsals. Conducting is a common avocation among singers but must be done with expert technique and special precautions to prevent voice injury. Hoarseness or loss of soft voice control after conducting a rehearsal suggest voice abuse during conducting.

Teaching singing may also be hazardous to vocal health. It can be done safely but requires skill and thought. Most teachers teach while seated at the piano. Late in a long, hard day, this posture is not conducive to maintenance of optimal abdominal and back support. Usually, teachers work with students continually positioned to the right or left of the keyboard. This may require the teacher to turn his or her neck at a particularly sharp angle, especially when teaching at an upright piano. Teachers also often demonstrate vocal materials in their students' vocal ranges rather than their own, illustrating bad as well as good technique. If a singing teacher is hoarse or has neck discomfort, or his or her soft singing control deteriorates at the end of a teaching day (assuming that the teacher warms up before beginning voice lessons), voice abuse should be suspected. Helpful modifications include teaching with a grand piano, sitting slightly sideways on the piano bench, or alternating student position to the right and left of the piano to facilitate better neck alignment. Retaining an accompanist so that the teacher can stand rather than teach from behind a piano and many other helpful modifications are possible.

General health

Singing is an athletic activity that requires good conditioning and coordinated interaction of numerous physical functions. Maladies of any part of the body may be reflected in the voice. Failure to exercise to maintain good abdominal muscle tone and respiratory endurance is particularly harmful in that deficiencies in these areas undermine the power source of the singing voice. Singers generally attempt to compensate for such weaknesses by using inappropriate muscle groups, particularly in the neck, causing vocal dysfunction. Similar problems may occur in the well-conditioned vocalist in states of fatigue. These are compounded by mucosal changes that accompany excessively long hours of hard work. Such problems may be seen even in the best singers shortly before important performances in the height of the concert season.

A popular but untrue myth holds that great opera singers must be obese. However, the vivacious, gregarious personality that often distinguishes the great performer seems to be accompanied frequently by a propensity for excess, especially culinary excess. This excess is as undesirable in the vocalist as it is in most other athletic artists, and it should be prevented from the start of one's vocal career. Appropriate and attractive body weight is becoming particularly important in the opera world as this formerly theatre-based artform moves to television and film media. However, attempts to effect weight reduction in an established singer are a different matter. The vocal mechanism is a finely tuned, complex instrument and is exquisitely sensitive to minor changes. Substantial fluctuations in weight frequently cause deleterious alterations of the voice, although these are usually temporary. Weight reduction programs for established singers must be monitored carefully and designed to reduce weight in small increments over long periods. A history of sudden recent weight

change may be responsible for almost any vocal complaint.

Singers usually volunteer information about upper respiratory tract infections and "postnasal drip", but the relevance of other maladies may not be obvious to them. Consequently the physician must seek out pertinent history. Acute upper respiratory tract infection causes inflammation of the mucosa, alters mucosal secretions, and makes the mucosa more vulnerable to injury. Coughing and throat clearing are particularly traumatic vocal activities and may worsen or provoke hoarseness associated with a cold. Postnasal drip and allergy may produce the same response. Infectious sinusitis is associated with discharge and diffuse mucosal inflammation, resulting in similar problems, and may actually alter the sound of a singer's voice, especially the singer's own perception of his or her voice. Futile attempts to compensate for disease of the supraglottic vocal tract in an effort to return the sound to normal frequently result in laryngeal strain. The expert singer compensates by monitoring technique rather than sound or singing "by feel" rather than "by ear".

Dental disease, especially temporomandibular joint dysfunction, introduces muscle tension in the head and neck, which is transmitted to the larynx directly through the muscular attachments between the mandible and the hyoid bone and indirectly as generalized increased muscle tension. These problems often result in decreased range, vocal fatigue, and change in the quality or placement of a voice. Such tension often is accompanied by excess tongue muscle activity, especially pulling of the tongue posteriorly. This hyperfunctional behavior acts through hyoid attachments to disrupt the balance between the intrinsic and extrinsic laryngeal musculature.

Reflux laryngitis is common among singers because of the high intraabdominal pressures associated with proper support and because of life-style requirements. Singers frequently perform at night. They generally refrain from eating before performances because a full stomach compromises effective abdominal support. They compensate at postperformance gatherings late at night and then go to bed with a full stomach. Chronic arytenoid and vocal fold irritation by reflux of gastric juice may be associated with dyspepsia, but the key features are a bitter taste and halitosis on awakening in the morning, a dry or "coated" mouth, often a scratchy sore throat or a feeling of a "lump in the throat", hoarseness, and the need for prolonged vocal warm-up. The physician must be alert to these symptoms and ask about them routinely; otherwise the diagnosis will often be overlooked because people who have had this problem for many years or a lifetime do not even realize it is abnormal. Hearing loss is often overlooked as a source of vocal problems. Auditory feedback is fundamental to singing. Interference with this control mechanism may result in altered vocal production, particularly if the singer is unaware of the hearing loss.

Any condition that alters abdominal function, such as muscle spasm, constipation, or diarrhea, interferes with support and may result in a voice complaint. These symptoms may accompany infection or anxiety.

The human voice is an exquisitely sensitive messenger of emotion. Highly trained singers learn to control the effects of anxiety and other emotional stresses on their voices under ordinary circumstances. However, in some instances this training may break down or a performer may be inadequately prepared to control the voice under specific stressful conditions. Preperformance anxiety is the most common example, but insecurity, depression,

and other emotional disturbances are also generally reflected in the voice. Anxiety reactions are mediated in part through the autonomic nervous system and result in a dry mouth, cold clammy skin, and thick secretions. These reactions are normal, and good vocal training coupled with assurance that no abnormality or disease is present generally overcomes them. However, long-term, poorly compensated emotional stress and exogenous stress (from agents, producers, teachers, parents, etc) may cause substantial vocal dysfunction and may result in permanent limitations of the vocal apparatus. These conditions must be diagnosed and treated expertly. Hypochondriasis is uncommon among professional singers, despite popular opinion to the contrary.

Endocrine dysfunction

Endocrine problems warrant special attention. The human voice is extremely sensitive to endocrinologic changes. Many of these are reflected in alterations of fluid content of the lamina propria just beneath the laryngeal mucosa. This causes alteration in the bulk and shape of the vocal folds and results in voice change. Hypothyroidism (Ritter, 1964, 1973; Michelsson and Servio, 1976; Gupta et al, 1977; Malinsky et al, 1977) is a well-recognized cause of such voice disorders, although the mechanism is not well understood. Hoarseness, vocal fatigue, muffling of the voice, loss of range, and a sensation of a lump in the throat may be present even with mild hypothyroidism. Even when thyroid function test results are within the low-normal range, this diagnosis should be entertained, especially if thyroid-stimulating hormone levels are in the high-normal range or are elevated. Thyrotoxicosis may result in similar voice disturbances (Malinsky et al, 1977).

Voice changes associated with sex hormones are encountered commonly in clinical practice and have been investigated more thoroughly than have other hormonal changes. Although a correlation appears to exist between sex hormone levels and depths of male voices (higher testosterone and lower estradiol levels in basses than in tenors) (Meuser and Nieschlag, 1977), the most important hormonal considerations in males are during the maturation process. When castrato singers were in vogue, castration at about age 7 or 8 resulted in failure of laryngeal growth during puberty and voices that stayed in the soprano or alto range and boasted a unique quality of sound (Brodnitz, 1975). Failure of a male voice to change at puberty is uncommon today and usually is psychogenic (Brodnitz, 1971). However, hormonal deficiencies such as those seen in cryptorchidism, delayed sexual development, Klinefelter's syndrome, or Fröhlich's syndrome may be responsible. In these cases, the persistently high voice may be the complaint that causes the patient to seek medical attention.

Voice problems related to sex hormones are more common in female singers. Although vocal changes associated with the normal menstrual cycle may be difficult to quantify with current experimental techniques, unquestionably they occur (von Gelder, 1974; Schiff, 1967; Wendler, 1972; Lacina, 1968). Most of the ill effects are seen in the immediate premenstrual period and are known as laryngopathia premenstrualis. This common condition is caused by physiologic, anatomic, and psychologic alterations secondary to endocrine changes. The vocal dysfunction is characterized by decreased vocal efficiency, loss of the highest notes in the voice, vocal fatigue, slight hoarseness, and some muffling of the voice. It is often more apparent to the singer than to the listener. Submucosal hemorrhages in the larynx are common (Lacina, 1968). In many European opera houses, singers are excused from

singing during the premenstrual and early menstrual days ("grace days"). This practice is not followed in the USA. Although ovulation inhibitors have been shown to mitigate some of these symptoms (Wendler, 1972), in some women (about 5%) birth control pills may deleteriously alter voice range and character even after only a few months of therapy (Dordain, 1972; Pahn and Goretzlehner, 1978; Schiff, 1968; Brodnitz, 1978). When oral contraceptives are used, the voice should be monitored closely. Under crucial performance circumstances, oral contraceptives may be used to alter the time of menstruation, but this practice is justified only in unusual situations.

Estrogens are helpful in postmenopausal singers but generally should not be given alone. Sequential replacement therapy is the most physiologic regimen and should be used under the supervision of a gynecologist. Under no circumstances should androgens be given to female singers even in small amounts if any reasonable therapeutic alternative exists. Clinically, these drugs are most commonly used to treat endometriosis. Androgens cause unsteadiness of the voice, rapid changes of timbre, and lowering of fundamental voice frequency (Damste, 1964, 1967; Saez and Françoise, 1975; Vourenkoski et al, 1978; Arndt, 1974; Bourdial, 1970). The changes are irreversible. In rare instances, androgens may be produced by pathologic conditions such as ovarian or adrenal tumors, and voice alterations may be the presenting symptoms. Rarely, they may also be secreted during an otherwise normal pregnancy. Pregnancy frequently results in voice alterations known as laryngopathia gravidarum. The changes may be similar to premenstrual symptoms or may be perceived as desirable changes. In some cases, alterations produced by pregnancy are permanent (Flach et al, 1968; Deuster, 1977).

Although hormonally induced changes in the larynx and respiratory mucosa secondary to menstruation and pregnancy are discussed widely in the literature, there has been no emphasis on the important alterations in abdominal support. Muscle cramping associated with menstruation causes pain and compromises abdominal contraction. Abdominal distension during pregnancy also interferes with abdominal muscle function. Any singer whose abdominal support is compromised substantially should be discouraged from singing until the disability is resolved. Hormonal disturbances in other segments of the diencephalic-pituitary system may also produce vocal dysfunction. In addition to the thyroid gland and the gonads, the parathyroid, adrenal, pineal, and pituitary glands are included in this system. Other endocrine disturbances may alter voice as well; for example, pancreatic dysfunction may cause xerophonia (dry voice), as in diabetus mellitus. Thymic abnormalities can lead to feminization of the voice (Imre, 1968).

Exposure to irritants

Any mucosal irritant can disrupt the delicate vocal mechanism. Allergies to dust and mold are aggravated commonly during rehearsals and performances in concert halls, especially older concert halls, because of the numerous curtains, backstage trappings, and dressing room facilities that are rarely cleaned thoroughly. Nasal obstruction and erythematous conjunctivas suggest generalized mucosal irritation. The drying effects of cold air and dry heat may also affect mucosal secretions, leading to decreased lubrication, a "scratchy" voice, and tickling cough. These symptoms may be minimized by nasal breathing, which allows inspired air to be filtered, warmed, and humidified. Nasal breathing rather than mouth breathing whenever possible is proper vocal technique. While the singer is backstage between appearances during

rehearsals, aspiration of dust and other irritants may also be controlled by wearing a protective mask such as those used by carpenters or a surgical mask that does not contain fiberglass. This is especially helpful when sets are being constructed in the rehearsal area.

A history of recent travel suggests other sources of direct irritation. The air in airplanes is extremely dry, and airplanes are noisy (Feder, 1984). Singers must be careful to avoid talking loudly and to maintain nasal breathing during air travel. Environmental changes can also be disruptive. Las Vegas is infamous for the mucosal irritation caused by its dry atmosphere and smoke-filled rooms. In fact, the resultant complex of hoarseness, vocal "tickle", and fatigue is referred to as "Las Vegas voice". A history of recent travel should also suggest jet lag and generalized fatigue, which may be potent detriments to good vocal function.

Smoke

The deleterious effects of tobacco smoke on mucosa are indisputable. It causes erythema, mild edema, and generalized inflammation throughout the vocal tract. Both smoke itself and the heat of the cigarette appear to be important. Marijuana produces a particularly irritating, unfiltered smoke that is inhaled directly, causing considerable mucosal response. The serious singers should not smoke. Singers who refuse to stop smoking marijuana should at least be advised to use a water pipe to cool and partially filter the smoke. Some singers are required to perform in smoke-filled environments and may suffer the same effects as the smokers themselves. In some theaters, it is possible to place fans upstage or direct the ventilation system so as to create a gentle draft toward the audience, clearing the smoke away from the stage. "Smoke eaters" installed in some theaters are also helpful.

Drugs

A history of alcohol abuse suggests the probability of poor vocal technique. Intoxication results in incoordination and decreased awareness, which undermine vocal discipline designed to optimize and protect the voice. The effect of small amounts of alcohol is controversial. Although many experts oppose it because of its vasodilatory effect and consequent mucosal alteration, many singers do not seem to be adversely affected by small amounts of alcohol such as a glass of wine with supper on the day of a performance. However, many singers have mild sensitivities to certain wines or beers. Singers who develop nasal congestion and rhinorrhea after drinking beer, for example, should be made aware that they probably have a mild allergy to that particular beverage and should avoid it before singing.

Singers frequently acquire antihistamines to help control "postnasal drip" or other symptoms. The drying effect of antihistamines may result in decreased vocal fold lubrication, increased throat clearing, and irritability leading to frequent coughing. Antihistamines may be helpful to some singers, but they must be used with caution.

When a singer seeking the attention of a physician is already taking antibiotics, it is important to find out the dose and the prescribing physician, if any, as well as whether the singer frequently treats himself or herself with inadequate courses of antibiotics. Singers sometimes have a "sore throat" shortly before performances and start themselves on

inappropriate antibiotic therapy, which they generally discontinue after their performance.

Diuretics are also popular among some singers. They are often prescribed by gynecologists at the singer's request to help deplete excess water in the premenstrual period. Unsupervised use of these drugs may cause dehydration and consequent mucosal dryness.

Hormone use, especially use of oral contraceptives, must be mentioned specifically during the physician's inquiry. Women frequently do not mention them routinely when asked whether they are taking any medication. Vitamins are also frequently not mentioned. Most vitamin therapy seems to have little effect on the voice. However, high-dose vitamin C (5 to 6 g/day), which some people use to prevent upper respiratory tract infections, seems to act as a mild diuretic and may lead to dehydration and xerophonia (Lawrence, 1978).

Cocaine use is increasingly common, especially among pop musicians. This drug can be extremely irritating to the nasal mucosa, causes marked vasoconstriction, and may alter the sensorium, resulting in decreased voice control and a tendency toward vocal abuse.

Foods

Various foods are said to affect the voice. Traditionally, singers avoid milk and ice cream before performances. In many people, these foods seem to increase the amount and viscosity of mucosal secretions. Allergy and casein have been implicated, but no satisfactory explanation has been established. Restriction of these foods in a singer's diet before a performance may be helpful in some cases. Chocolate may have the same effect and should be viewed similarly. Singers should be asked about eating nuts. This is important not only because some people feel they produce effects similar to those of milk products and chocolate but because they are extremely irritating if aspirated. The irritation produced by aspiration of a small organic foreign body may be severe and impossible to correct rapidly enough to permit performance. Highly spiced foods may also be mucosal irritants; in addition, they seem to aggravate reflux laryngitis. Coffee and other beverages containing caffeine also aggravate gastric reflux and seem to alter secretions and necessitate frequent throat clearing in some people. In large quantities they may also cause hyperactivity and tremor. Fad diets, especially rapid-weight-reducing diets, are notorious for causing voice problems. Lemon juice and herbal teas are both considered beneficial to the voice. Both may act as demulcents, thinning secretions, and may very well be helpful.

When inquiring about foods, the physician should ask whether the singer eats immediately before singing. A full stomach may interfere with abdominal support or may cause reflux of gastric juice during abdominal muscle contraction.

Surgery

A history of laryngeal surgery in a professional singer is a matter of great concern. It is important to establish exactly why the surgery was done, by whom it was done, whether intubation was necessary, and whether ancillary speech training was instituted if the lesion was associated with voice abuse (vocal nodules). If the vocal dysfunction that sent the singer to the physician's office dates from the immediate postoperative period, surgical trauma must be suspected.

Otolaryngologists frequently are asked about the effects of tonsillectomy on the voice. Singers may consult the physician after tonsillectomy and complain of vocal dysfunction. Certainly removal of tonsils can alter the voice (Gould et al, 1978; Wallner et al, 1968). Tonsillectomy changes the configuration of the supraglottic vocal tract. In addition, scarring alters pharyngeal muscle function, which is trained meticulously in the professional singer. Singers must be warned that they may have permanent voice changes after tonsillectomy; these can be minimized by dissecting in the proper plane to lessen scarring. The singer's voice generally requires 3 to 6 months to stabilize or return to normal after surgery. As with any procedure for which general anesthesia may be needed, the anesthesiologist should be advised preoperatively that the patient is a professional singer. Intubation and extubation should be performed with great care and with nonirritating plastic rather than rubber tubes.

Surgery of the neck, such as thyroidectomy, may result in permanent alterations in the vocal mechanism through scarring of the extrinsic laryngeal musculature. The cervical (strap) muscles are important in maintaining laryngeal position and stability of the laryngeal skeleton and should be retracted rather than divided whenever possible. A history of recurrent or superior laryngeal nerve injury may explain a hoarse, breathy, or weak voice. However, in rare cases a singer can compensate even for recurrent laryngeal nerve paralysis and have a nearly normal voice.

Thoracic and abdominal surgery interferes with respiratory and abdominal support. After these procedures singing should be prohibited until pain has subsided and healing has occurred sufficiently to allow normal support. Frequently, abdominal exercises should be instituted before resumption of vocalizing. Singing without proper support is worse for the voice than not singing at all. I require that singers be able to do 10 sit-ups before resuming singing after abdominal or thoracic surgery.

Other surgical procedures may be important factors if they necessitate intubation or if they affect the musculo-skeletal system so that the singer has to change stance or balance. For example, balancing on one foot after leg surgery may decrease the effectiveness of the singer's support mechanisms.

Physical Examination

A comprehensive history frequently reveals the cause of a singer's problem even before a physical examination is performed. However, a specialized physical examination, often including objective assessment of voice function, is essential (Sataloff, 1981, 1987, 1991).

As with any patient, examination of the professional singer must include an assessment of general physical condition and a thorough ear, nose, and throat evaluation. Like any athletic activity, singing requires stamina and reasonably good physical conditioning. Any physical condition that impairs normal function of the abdominal musculature is suspect as a cause of dysphonia. Some such conditions, such as pregnancy, are obvious. However, a sprained ankle or broken leg that requires the singer to balance in an unaccustomed posture may distract him or her from maintaining good abdominal support and may result in voice dysfunction. Any neurologic disorder that results in tremor, endocrine disturbances such as thyroid dysfunction or menopause, the aging process, and other systemic conditions also may

alter the voice. The physician must remember that maladies of almost any body system may cause voice dysfunction and must remain alert to conditions outside the head and neck.

Complete ear, nose, and throat examination

Examination of the ears must include assessment of hearing acuity. Even a relatively slight hearing loss may result in voice strain as the singer tries to balance his or her vocal intensity with that of associate performers. This is especially true of hearing losses acquired after vocal training has been completed. The effect is most pronounced with sensorineural hearing loss. With conductive hearing loss, singers tend to sing more softly than appropriate rather than too loudly, and this is less harmful.

During an ear, nose, and throat examination the conjunctivae and sclerae should be observed routinely for erythema that suggests allergy or irritation, for pallor that suggests anemia, and for other abnormalities such as jaundice. These observations may reveal the problem reflected in the vocal tract even before the larynx is visualized.

The nose should be assessed for patency of the nasal airway, character of the nasal mucosa, and nature of secretions, if any. A singer who is unable to breathe through the nose because of anatomic obstruction is forced to breathe unfiltered, unhumidified air through the mouth. Pale gray allergic mucosa or swollen infected mucosa in the nose suggests abnormal mucosa elsewhere in the respiratory tract.

Examination of the oral cavity should include careful attention to the tonsils and lymphoid tissue in the posterior pharyngeal wall, as well as to the mucosa. Diffuse lymphoid hypertrophy associated with a complaint of "scratchy" voice and irritative cough may indicate chronic infection. The amount and viscosity of mucosal and salivary secretions should be noted also. Xerostomia (dry mouth) is particularly important. Dental examination should focus not only on oral hygiene but also on the presence of wear facets suggestive of bruxism (tooth grinding). Bruxism is a clue to excessive tension and may be associated with dysfunction of the temporomandibular joints, which should also be assessed routinely. Thinning of the enamel of the central incisors in a normal or underweight patient may be a clue to bulimia. However, it may also result from excessive ingestion of lemons, which some singers eat to help thin their secretions.

The neck should be examined for masses, restriction of movement, excess muscle tension, and scars from prior neck surgery or trauma. Examination of posterior neck muscles and range of motion should not be neglected. Particular attention should be paid to the thyroid gland. Laryngeal vertical mobility is also important; for example, tilting of the larynx produced by partial fixation of cervical muscles cut during previous surgery may produce voice dysfunction, as may fixation of the trachea to overlying neck skin. The cranial nerves should also be examined. Diminished fifth nerve sensation, diminished gag reflex, palatal deviation, or other mild cranial nerve deficits may indicate mild cranial polyneuropathy. Post-viral-infection neuropathies may involve the superior laryngeal nerve and cause weakness, fatigability, and loss of range in the singing voice. More serious neurologic disease may also be associated with such symptoms and signs.

Laryngeal examination

Examination of the larynx begins when the singer enters the physician's office. The range, ease, volume, and quality of the speaking voice should be noted. Technical voice classification is beyond the scope of most physicians. However, the physician should at least be able to discriminate substantial differences in range and timbre such as between bass and tenor, or alto and soprano. Although the correlation between speaking and singing voices is not perfect, a speaker with a low comfortable bass voice who reports that he is a tenor may be misclassified and singing inappropriate roles with consequent voice strain. This judgment should be deferred to an expert, but the observation should lead the physician to make the appropriate referral. Excessive volume or obvious strain during speaking clearly indicates that voice abuse is present and may be contributing to the patient's singing complaint.

Any patient with a voice problem should be examined by indirect laryngoscopy at least. Judging voice ranges, quality, or other vocal attributes by inspection of the vocal cords is not possible. However, the presence or absence of nodules, mass lesions, contact ulcers, hemorrhage, erythema, paralysis, arytenoid erythema (reflux), and other anatomic abnormalities must be established. Erythema of the laryngeal surface of the epiglottis is often associated with frequent coughing or clearing of the throat and is caused by direct trauma from the arytenoids during these maneuvers. A mirror or laryngeal telescope often provides a better view of the posterior portion of the vocal folds than is obtained with flexible endoscopy. Stroboscopic examination adds substantially to diagnostic ability; a stroboscopic light source can be directed at the physician's head mirror, permitting good assessment of laryngeal vibration. Such an examination frequently reveals vibratory irregularities that would be overlooked in routine examination. Another helpful adjunct is the operating microscope. Magnification allows visualization of small mucosal disruptions and hemorrhages that may be important but otherwise overlooked. This technique also allows photography of the larynx with a microscope camera. Magnification may also be achieved through magnifying laryngeal mirrors or by loupes. Loupes usually provide a clearer image than most of the magnifying mirrors available. Laryngeal telescopes are also extremely useful and allow photography, magnification, stroboscopy, and excellent visualization.

Fiberoptic laryngoscopy can be performed as an office procedure and allows inspection of the vocal folds in patients whose vocal folds are difficult to visualize indirectly. In addition, it permits observation of the vocal mechanism in a more natural posture than does indirect laryngoscopy. In the hands of an experienced endoscopist, this method may provide a great deal of information about both speaking and singing voices. The combination of a fiberoptic laryngoscope with a laryngeal stroboscope may be especially useful (Gould et al, 1979). This system permits magnification, photography, and detailed inspection of vocal fold motion. More sophisticated systems that permit fiberoptic stroboscovideolaryngoscopy are currently available commercially. They are an invaluable asset for routine clinical use. The video system also provides a permanent record, permitting reassessment, comparison over time, and easy consultation with other physicians. A refinement not currently available commercially is stereoscopic fiberoptic laryngoscopy, accomplished by placing a laryngoscope through each nostril, fastening the two together in the pharynx, and observing the larynx through the eyepieces (Fujimara, 1979). This method allows excellent visualization of laryngeal motion in three dimensions. However, it is practical primarily in a research setting.

Rigid endoscopy with anesthesia may be reserved for the rare patient whose vocal folds cannot be assessed adequately by other means or for patients who need surgical procedures to remove or obtain biopsy specimens of laryngeal lesions. In many cases this may be done with local anesthesia, avoiding the need for intubation and the traumatic coughing and vomiting that may occur even after general anesthesia administered by mask. Coughing after general anesthesia may be minimized by using topical anesthesia in the larynx and trachea. However, topical anesthetics may act as severe mucosal irritants in a small number of patients. They may also predispose the patient to aspiration in the postoperative period. If a singer has had difficulty with a topical anesthetic in the office, it should not be used in the operating room. When used, topical anesthetic should be applied at the end of the procedure. Thus, if inflammation occurs, it will not interfere with microsurgery. Postoperative duration of anesthesia is also optimized. I have had the least difficulty with 4% xylocaine.

Objective tests

Reliable, valid, objective analysis of the voice is extremely important. It is as invaluable to the laryngologist as audiometry is to the otologist (Sataloff et al, 1990). Familiarity with some of the measures currently available is helpful.

A battery of objective tests that allows reliable, valid, objective assessment of subtle changes in voice function - a "meter of the voice" - is needed. This development is necessary not only to treat professional singers but also to assess the results of laryngeal surgery and treatment for spasmodic dysphonia and other conditions and to help diagnose the many systemic diseases associated with voice change. Reporting that a patient's voice "is better" without objective measures is as unsatisfactory as reporting that a patient's hearing is better without an audiogram. A few objective tests are discussed in the following sections. Each may be clinically useful in selected circumstances, and they may well be forerunners in a new era of routine objective voice assessment.

Stroboscovideolaryngoscopy

Stroboscovideolaryngoscopy is the single most important technologic advance in diagnostic laryngology with the possible exception of fiberoptic laryngoscopy. Stroboscopic light allows routine slow-motion evaluation of the mucosal cover layer of the leading edge of the vocal fold. This improved physical examination permits detection of vibratory asymmetries, structural abnormalities, small masses, submucosal scars, and other conditions that are invisible under ordinary light (Sataloff et al, 1988a). For example, in a patient who has a poor voice after laryngeal surgery and a "normal-looking larynx", stroboscopic light reveals adynamic segments that explain the problem even to an untrained observer (such as the patient). The stroboscope is also extremely sensitive in detecting changes caused by fixation from small laryngeal neoplasms in patients who are being followed for leukoplakia or after laryngeal irradiation. Coupling stroboscopic light with the video camera allows later reevaluation by the laryngologist or other physicians.

A relatively standardized method of subjective assessment of video stroboscopic pictures is in wide clinical use (Hirano, 1975; Bless et al, 1987), allowing comparison of results among various physicians and investigators. Characteristics assessed include fundamental frequency, symmetry of bilateral movements, periodicity, glottal closure,

amplitude, mucosal wave, presence of nonvibrating portions, and other unusual findings (such as a tiny polyp). In addition, objective frame-by-frame computer analysis is also possible, although not yet practical (or necessary) on a routine clinical basis.

Other techniques to examine vocal fold vibration

Ultra-high-speed photography provides images similar to those with stroboscovideolaryngoscopy but requires expensive, cumbersome equipment and delayed data processing. *Electroglottography* (EGG) uses two electrodes on the skin of the neck above the thyroid laminae. A weak, high-frequency voltage is passed through the larynx from one electrode to the other. Opening and closing of the vocal cords vary the transverse electrical impedance, producing variation of the electrical current in phase with vocal fold vibration. The resulting tracing is called an electroglottogram. It traces the opening and closing of the glottis and can be compared with stroboscopic images (Leclure et al, 1975). Electroglottography allows objective determination of the presence or absence of glottal vibrations and easy determination of the fundamental period of vibration and is reproducible. It reflects the glottal condition more accurately during its closed phase, and quantitative interpretation of the glottic condition is probably not valid (Hirano, 1981). EGG shows increasing promise of clinical usefulness (Scherer et al, 1988). *Photoelectroglottography* and *ultrasoundglottography* are less useful clinically (Hirano, 1981).

Measures of phonatory ability

Objective measures of phonatory ability are among the easiest and most readily available to the laryngologist, helpful in treatment of professional vocalists with specific voice disorders, and extremely useful in assessing the results of surgical therapies. *Maximum phonation time* is measured with a stopwatch. The patient is instructed to sustain the vowel /e/ for as long as possible after deep inspiration, vocalizing at a comfortable frequency and intensity. In select cases, the frequency and intensity may be controlled by an inexpensive frequency analyzer and sound level meter. The test is repeated three times, and the greatest value is recorded. Normal values have been determined (Hirano, 1981). *Frequency range of phonation* is recorded in semitones and records the vocal range from the lowest note in the modal register (excluding vocal fry) to the highest falsetto note. This the *physiologic* frequency range of phonation and disregards quality. The *musical* frequency range of phonation measures lowest to highest musically acceptable qualities. Tests for maximum phonation time, frequency range, and many of the other parameters discussed later (including spectrographic analysis) may be preserved on a tape recorded for analysis at a convenient future time and used for pretreatment and posttreatment comparisons. Recordings should be made in a standardized, consistent fashion.

Frequency limits of *vocal register* may also be measured. The registers are (from low to high) vocal fry, chest, mid, head, and falsetto. Overlap of frequency among registers occurs routinely. Testing the *speaking fundamental frequency* often reveals excessively low pitch, an abnormality associated with chronic voice abuse and development of vocal nodules. This parameter may be followed objectively throughout a course of speech therapy. *Intensity range of phonation* (IRP) has proved a less useful measure than frequency range. It varies with fundamental frequency (which should be recorded) and is greatest in the middle frequency

range. It is recorded in sound pressure level (SPL) relative to 0.0002 microbar. For normal adults who are not professional vocalists, measuring at a single fundamental frequency, IRP averages 54.8 dB for males and 51 dB for females (Coleman et al, 1977). Alterations of intensity are common in voice disorders, although IRP is not the most sensitive test to detect them. Information from these tests may be combined in the *fundamental frequency-intensity profile* (Hirano, 1981).

Glottal efficiency (ratio of the acoustic power at the level of the glottis to subglottic power) provides useful information but is not clinically practical because measuring acoustic power at the level of the glottis is difficult. *Subglottic power* is the product of *subglottal pressure* and *airflow rate*. These can be determined clinically. Various alternative measures of glottic efficiency have been proposed, including the *ratio of radiated acoustic power to subglottal power* (Isshiki, 1964), *airflow-intensity profile* (Saito, 1977), and *ratio of the root mean square value of the AC component to the mean volume velocity (DC component)* (Isshiki, 1977). Although glottal efficiency is of great interest, none of these tests is particularly helpful under routine clinical circumstances.

Aerodynamic measures

The abdomen and thorax form the "power source" of the voice, propelling a controlled stream of air between the vocal folds. Singers refer to this anatomic complex as the "diaphragm" or "support". Effective, well-trained abdominal-thoracic muscle control and efficient respiratory function are essential to healthy vocalization. Traditional pulmonary function testing provides the most readily accessible measure of respiratory function. The most common parameters measured are (1) *tidal volume*, the volume of air that enters the lungs during inspiration and leaves during expiration in normal breathing; (2) *functional residual capacity*, the volume of air remaining in the lungs at the end of expiration during normal breathing, which may be divided into expiratory reserve volume (maximal additional volume that can be exhaled) and residual volume (volume of air remaining in the lungs at the end of maximal exhalation); (3) *inspiratory capacity*, the maximal volume of air that can be inhaled starting at the functional residual capacity; (4) *total lung capacity*, the volume of air in the lungs after maximal inspiration; (5) *vital capacity*, the maximum volume of air that can be exhaled from the lungs after maximal inspiration; (6) *forced vital capacity*, the rate of airflow with rapid, forceful expiration from total lung capacity to residual volume; (7) *FEV1*, the forced expiratory volume in 1 second; (8) *FEV3*, forced expiratory volume in 3 seconds; (9) *maximum midexpiratory flow rate* or *forced midexpiratory flow*, the mean rate of airflow over the middle half of the forced vital capacity (between 25% and 75% of the forced vital capacity).

For most established singers, routine pulmonary function testing is not helpful. However, for singers and professional speakers with abnormality caused by voice abuse, abnormal pulmonary function tests may confirm deficiencies in aerobic conditioning or reveal previously unrecognized asthma. Testing before and after bronchodilator therapy helps establish this diagnosis. In selected instances, when asthma is suspected clinically, methacholine challenge is justified. Even a mild or moderate obstructive pulmonary disease may have a substantial deleterious effect on the voice; significant asthma may be present, even in the absence of wheezing. Sometimes chronic cough or voice abuse may be the only

presenting symptom.

The spirometer, readily available for pulmonary function testing, can be used for measuring airflow during phonation. However, it does not allow simultaneous display of acoustic signals, and its frequency response is poor. A pneumotachograph consists of a laminar air resistor, a differential pressure transducer, and an amplifying and recording system. It allows measurement of airflow and simultaneous recording of other signals when coupled with a polygraph. A hotwire anemometer allows determination of airflow velocity by measuring the electrical drop across the hot wire. Modern hot-wire anemometers that contain electrical feedback circuitry that maintains the temperature of the hot wire provide a flat frequency response up to 1 kHz and are useful clinically (Isshiki, 1977).

The four parameters traditionally measured in analyzing the aerodynamic performance of a voice are subglottal pressure (P_{sub}), supraglottal pressure (P_{sup}), glottal impedance, and volume velocity of airflow at the glottis. These parameters and their rapid variations can be measured under laboratory circumstances. However, clinically their mean value is usually determined. They are related as follows:

$$P_{sub}P_{sup} = MFR \times GR$$

where MFR is the mean (root mean square) flow rate and GR is the mean (root mean square) glottal resistance. When vocalizing an open vowel, the supraglottic pressure equals the atmospheric pressure, reducing the equation to

$$P_{sub} = MFR \times GR.$$

The *mean flow rate* is a useful clinical measure. While the patient vocalizes the vowel "ah", the mean flow rate is calculated by dividing the total volume of air used during phonation by the duration of phonation. The subject phonates at a natural pitch and loudness either over a determined time or for a maximum sustained period of phonation.

Air volume is determined by the use of a mask fitted tightly over the face or by phonation into a mouthpiece while wearing a nose clamp. Measurements may be made by a spirometer, pneumotachograph, or hot-wire anemometer. The normal values for mean flow rate under habitual phonation, with changes in intensity or register, and under various pathologic circumstances have been determined (Hirano, 1981). Normal values are available for both adults and children. Mean flow rate is a clinically useful parameter to follow during treatment for vocal nodules, recurrent laryngeal nerve paralysis, spasmodic dysphonia, and other conditions.

Glottal resistance cannot be measured directly, but it may be calculated from the mean flow rate and mean subglottal pressure. Normal glottal resistance is 20 to 100 dyne-sec/cm⁵ at low and medium pitches and 150 dyne-sec/cm⁵ at high pitches (Isshiki, 1964). *Subglottal pressure* less useful clinically because it requires an invasive procedure for accurate measurement. It may be determined by tracheal puncture, transglottal catheter, or measurement through a tracheostoma using a transducer. Subglottal pressure may be approximated by using an esophageal balloon. *Intratracheal pressure*, which is roughly equal to subglottal pressure, is transmitted to the balloon through the trachea. However, measured

changes in the esophageal balloon are affected by intraesophageal pressure, which depends on lung volume. Therefore, estimates of subglottal pressure using this technique are valid only under specific controlled circumstances. The normal values for subglottal pressure under various healthy and pathologic voice conditions have also been determined by numerous investigators (Hirano, 1981).

The *phonation quotient* is the vital capacity divided by the maximum phonation time. This value has been shown to be correlated closely with maximum flow rate (Hirano et al, 1968) and is a more convenient measure. Normative data determined by various authors have been published (Hirano, 1981). The phonation quotient provides an objective measure of the effects of treatment and is particularly useful in cases of recurrent laryngeal nerve paralysis and mass lesions of the vocal folds, including nodules.

Acoustic analysis

Acoustic analysis of voice signals is both promising and disappointing. The skilled laryngologist, speech pathologist, musician, or other trained listener frequently infers a great deal of valid information from the sound of a voice. However, clinically useful technology for analyzing and quantifying subtle acoustic differences has not been developed. In many ways, the tape recorder is still the laryngologist's most valuable tool for acoustic analysis. Recording a patient's voice under controlled, repeatable circumstances before, during, and at the conclusion of treatment allows both the physician and the patient to make a qualitative, subjective acoustic analysis. Objective analysis with instruments may also be made from recorded voice samples.

Care must be taken to use a standardized protocol. Probably the most widely used instrument for acoustic analysis in the USA is the Visi-pitch (Kay Elemetrics), which is useful in many ways but has limitations (Sataloff, 1991). Spectrography has been readily available for many years. Traditionally a spectrograph has displayed the frequency and harmonic spectrum of a short sample of voice and visually recorded noise. In addition to routine spectrographs, other equipment is used to analyze longer voice samples. Long-time-average-spectrograph (LTAS) devices analyze spectral distribution of speech amplitude levels over time (Frokjaer-Jensen and Prytzen, 1976), providing additional information.

The DSP Sona-Graph Model 5500 (Kay Elemetrics) is an integrated voice analysis system. It is equipped for sound spectrography capabilities. Spectrography provides a visual record of the voice. The acoustic signal is depicted using time (x axis), frequency (y axis), and intensity (z axis, shading of light versus dark). With the band pass filters, generalizations about quality, pitch, and loudness can be made. These observations are used in formulating the voice therapy treatment plan. Formant structure and strength can be determined by the narrow-band filters, of which a variety of configurations are possible. In those clinical settings where singers and other professional voice users are routinely evaluated and treated, this feature is extremely valuable. A sophisticated voice analysis program (an optional program) has made the Sona-Graph an especially valuable addition to the clinical laboratory. The voice analysis program measures speaking fundamental frequency, frequency perturbation (jitter), amplitude perturbation (shimmer), and harmonics/noise ratio and provides a breathiness index. An EGG is used in conjunction with the Sona-Graph to provide these voicing parameters. Examining the EGG waveform alone is possible with this setup, but its clinical usefulness has

not yet been established. An important feature of the Sona-Graph is the long-term average (LTA) spectral capability, which allows analysis of longer voice samples (30 to 90 seconds). The LTA analyzes only voiced speech segments and may be useful in screening for hoarse or breathy voices. In addition, computer interface capabilities (also an optional program) have solved many data storage and file maintenance problems. One important temporary disadvantage of the Sona-Graph is that currently normative data with which to compare the voicing parameters are limited. This problem should be solved quickly as this valuable instrument is used more widely and additional data are published.

In analyzing acoustic signals, the microphone may be placed at the mouth or may be positioned in or over the trachea. However, position should be standardized in each office or laboratory (Price and Sataloff, 1988). Various techniques are being developed to improve the usefulness of acoustic analysis, including inverse filtering and various multidimensional approaches to analysis. Because of the enormous amount of information carried in the acoustic signal, further refinements in objective acoustic analysis should prove particularly valuable to the clinician.

Laryngeal electromyography

Electromyography requires an electrode system, an amplifier, an oscilloscope, a loudspeaker, and a recording system. Either a needle electrode or a hooked-wire electrode may be used (Hirano, 1981). Because of the invasive nature of the procedure, electromyography is rarely used in caring for the customary problems of professional voice users. However, it may be extremely valuable in confirming cases of vocal fold paralysis, in differentiating paralysis from arytenoid dislocation, in distinguishing recurrent laryngeal nerve paralysis from complete vocal fold paralysis, and in documenting functional voice disorders and malingering. It is also recommended for needle localization when using botulinum toxin.

Psychoacoustic evaluation

Because the human ear and brain are the most sensitive and complex analyzers of sound currently available, many researchers have tried to standardize and quantify psychoacoustic evaluation. Unfortunately, even definitions of basic terms such as *hoarseness* and *breathiness* are still controversial. Psychoacoustic evaluation protocols and interpretation are not standardized. Consequently, although subjective psychoacoustic analysis of voice is of great value to the individual skilled clinician, it remains generally unsatisfactory for comparing research among laboratories or for reporting clinical results.

Evaluation of the singing voice

The physician's evaluation of the larynx is aided greatly by examination of the singing voice. This is accomplished best by asking the singer to stand and sing scales either in the examining room or in the soundproof audiology booth. The physician must be careful not to exceed the limits of his or her expertise. However, if voice abuse or technical error is suspected, or if a difficult judgment must be reached on whether to allow a sick singer to perform, a brief observation of the patient's singing may provide invaluable information. The singer's stance should be balanced, the weight slightly forward. The knees should be bent slightly and the shoulders, torso, and neck relaxed. The singer should inhale through the nose.

This allows filtration, warming, and humidification of inspired air. In general, the chest should be expanded, but most of the active breathing is abdominal. The chest should not rise substantially, and the supraclavicular musculature should not be involved obviously in inspiration. Shoulders and neck muscles should not be tensed even with deep inspiration. Abdominal musculature should be contracted before the initiation of the tone. This may be evaluated visually or by palpation (Fig. 109-2). Muscles of the neck and face should be relaxed. Economy is a basic principle of all artforms. Wasted energy and motion and muscle tension are incorrect and usually deleterious.

The singer should be instructed to sing a scale (a five-note scale is usually sufficient) on the vowel /a/, beginning on any comfortable note. Technical errors are usually most obvious as contraction of muscles in the neck and chin, retraction of the lower lip, retraction of the tongue, or tightening of the muscles of mastication. The singer's mouth should be open widely but comfortably. When singing /a/, the singer's tongue should rest in a neutral position with the tip of the tongue lying against the back of the singer's teeth. If the tongue pulls back or demonstrates obvious muscular activity as the singer performs the scales, improper voice use can be confirmed on the basis of positive evidence (Fig. 109-3). The position of the larynx should not vary substantially with pitch changes. Rising of the larynx with ascending pitch is also evidence of technical dysfunction (Fig. 109-4). This examination also gives the physician an opportunity to observe any dramatic differences between the qualities and ranges of the speaking voice and the singing voice. A laryngeal examination summary has proved helpful in organization and documentation (Sataloff, 1987) (see box).

Remembering the admonition not to exceed his or her expertise, the physician who examines many singers can often glean invaluable information from a brief attempt to modify an obvious technical error. For example, deciding whether to allow a singer with mild or moderate laryngitis to perform is often difficult. On the one hand, an expert singer has technical skills that allow him or her to sing around adverse circumstances safely; on the other hand, if a singer does not sing with correct technique and does not have the discipline to modify volume, technique, and repertoire as necessary, the risk of vocal injury may be increased substantially even by mild inflammation of the vocal cords. In borderline circumstance, observation of the singer's technique may greatly help the physician in making a judgment.

If the technique appears flawless, we may feel somewhat more secure in allowing the singers to proceed with performance commitments. More commonly, even good singers demonstrate technical errors when they have laryngitis. In a vain effort to compensate for dysfunction at the vocal fold level, singers often modify their technique in the supraglottic or subglottic vocal tract. In the good singer, this usually means going from good technique to bad technique. The most common error involves pulling back the tongue and tightening the cervical muscles. Although this increased muscular activity gives the singer the illusion of making the voice more secure, this technical maladjustment undermines the effectiveness of support and increases vocal strain. The physician may ask the singer to hold the top note of a five-note scale; while the note is being held, the singer may simply be told, "Relax your tongue". At the same time the physician points to the singer's abdominal musculature; most good singers immediately correct to good technique. If they do, and if upcoming performances are particularly important, the singer may be able to perform with a reminder that meticulous technique is essential. The singer should be advised to "sing by feel rather

than by ear" to consult his or her voice teacher, and conserve the voice except when it is absolutely necessary to use it. If a singer is unable to correct from bad technique to good technique promptly, especially if he or she uses excessive muscle tension in the neck and ineffective abdominal support, it is generally safer not to perform with even mild vocal cord abnormality. With increased experience and training, the laryngologist may make other observations that aid in providing appropriate treatment recommendations for singer patients.

If treatment is to be instituted, at least a tape recording of the voice is advisable in most cases and essential before any surgical intervention. I routinely use stroboscovideolaryngoscopy for diagnosis and documentation in virtually all cases as well as many of the objective measures discussed. Such testing is extremely helpful clinically and medicolegally.

Other appropriate examination

A general physical examination should be performed whenever the patient's systemic health is questionable. Debilitating conditions such as mononucleosis may be noticed first by the singer as vocal fatigue. A neurologic assessment may be particularly revealing. The physician must be careful not to overlook dysarthrias and dysphonias characteristic of movement disorders and of serious neurologic disease. Dysarthria is a defect in rhythm, enunciation, and articulation that usually results from neuromuscular impairment or weakness such as may occur after a stroke. It may be seen with oral deformities or illness, as well. Dysphonia is an abnormality of vocalization usually originating from problems at the laryngeal level.

Physicians should be familiar with the six types of dysarthria, their symptoms, and their importance (Darley et al, 1969a, 1969b). *Flaccid dysarthria* occurs in lower motor neuron or primary muscle disorders such as myasthenia gravis and tumors or strokes involving the brainstem nuclei. *Spastic dysarthria* occurs in upper motor neuron disorders (pseudobulbar palsy) such as multiple strokes and cerebral palsy. *Ataxic dysarthria* is seen with cerebellar disease, alcohol intoxication, and multiple sclerosis. *Hypokinetic dysarthria* accompanies Parkinson's disease. *Hyperkinetic dysarthria* may be spasmodic, as in the Gilles de la Tourette's disease, or dystonic, as in chorea and cerebral palsy. *Mixed dysarthria* occurs in amyotrophic lateral sclerosis. The preceding classification actually combines dysphonic and dysarthric characteristics but is very useful clinically. The value of a comprehensive neurolaryngologic evaluation cannot be overstated (Rosenfield, 1987). More specific details of voice changes associated with neurologic dysfunction and their localizing value are available elsewhere (Aronson, 1985; Sataloff, 1991).

Even "minor" problems may produce disturbing or disabling effects in a professional performer who requires nearly perfect physical function.

Common Diagnoses and Treatments

In 2286 cases of all forms of voice disorders reported by Brodnitz (1971), 80% of the disorders were attributed to voice abuse or to psychogenic factors resulting in vocal dysfunction. Of these patients 20% had organic voice disorders. Of women with organic problems, about 15% had identifiable endocrine causes. A much higher incidence of organic

disorders, particularly reflux laryngitis and acute infectious laryngitis, may be found more commonly.

Reflux laryngitis

Reflux laryngitis is caused by regurgitation of gastric acid into the hypopharynx. The symptoms discussed previously and the bright red, often slightly edematous appearance of the arytenoid mucosa help establish the diagnosis. A barium esophagram may provide additional information but is not needed routinely. In selected cases, 24-hour pH monitoring provides the best analysis and documentation of reflux. The mainstays of treatment are elevation of the head of the singer's bed (not just sleeping on pillows), use of antacids, and avoidance of food for 3 or 4 hours before sleep. Avoidance of alcohol and coffee is beneficial. Cimetidine, ranitidine, or famotidine also may be helpful, if the patient has no contraindications to their use. In this relatively young patient population, it should be remembered that male infertility is one of the complications (although uncommon) of cimetidine use.

Anxiety

Good singers are frequently sensitive and communicative people. When the principal cause of vocal dysfunction is anxiety, the physician can often accomplish much by assuring the patient that no organic difficulty is present and by stating the diagnosis of anxiety reaction. The singer should be counseled that anxiety is normal and that recognition of it as the principal problem frequently allows the performer to overcome it. Tranquilizers and sedatives are rarely necessary and are undesirable because they may interfere with fine motor control. Recently, beta-adrenergic blocking agents such as propranolol hydrochloride (eg, Inderal) have achieved some use in the treatment of pre-performance anxiety. I do not recommend beta-blockers for regular use: they have significant effects on the cardiovascular system and many potential complications, including hypotension, thrombocytopenic purpura, mental depression, agranulocytosis, laryngospasm with respiratory distress, and bronchospasm. In addition, their efficacy is controversial. Although they may have a favorable effect in relieving performance anxiety, beta-blockers may produce a noticeable adverse effect on singing performance (Gates et al, 1985). As blood level of drugs established by a given dose of beta-blocker varies widely among individuals, initial use of these agents before performances may be particularly troublesome. In addition, beta-blockers impede increases in heart rate, which are needed as physiologic responses to the psychologic and physical demands of performance. Although these drugs have a place under occasional, extraordinary circumstances, their routine use not only is potentially hazardous but also violates an important therapeutic principle.

Performers have chosen a career that exposes them to the public. If such persons are so incapacitated by anxiety that they are unable to perform the routine functions of their chosen profession without chemical help, this should be considered symptomatic of an important underlying psychologic problem. For a performer to depend on drugs to perform - whether the drug is a benzodiazepine, a barbiturate, a beta-blocker, or alcohol - is neither routine nor healthy. If such dependence exists, psychologic evaluation should be considered by an experienced arts-medicine psychologist or psychiatrist. Obscuring the symptoms by fostering the dependence is insufficient. However, if the singer is on tour and will only be under a particular laryngologist's care for a week or two, the physician should not try to make

major changes in his or her customary regimen. Rather, he or she should communicate with the performer's primary laryngologist or family physician and coordinate appropriate long-term care through him or her.

Muscle problems

The physician must not exceed the limits of his or her expertise or responsibility. However, a physician who is trained in singing and notices a minor technical error such as isolated excess muscle tension in the tongue may point this out. Nevertheless, the singer should be referred to his or her voice teacher or to a competent phoniatrist for management of these problems. Abdominal muscle problems should be noted and also referred to the vocal teacher. Of course, any medical cause must be corrected. A skilled dentist can usually easily manage dental and temporomandibular joint problems.

Voice abuse

When voice abuse is due to nonsinging activities such as conducting, screaming at athletic events, or shouting at children, the physician should advise the patient about measures to protect the speaking voice and, consequently, the singing voice. However, if the cause is strain in the singing or speaking voice under ordinary circumstances, treatment should be deferred to a voice teacher or speech pathologist. In many instances, training the speaking voice will benefit the singer greatly and physicians should not hesitate to recommend such training.

Vocal nodules, cysts, and polyps

Nodules are caused by voice abuse and are a dreaded malady of singers. Occasionally, laryngoscopy reveals asymptomatic vocal nodules that do not appear to interfere with voice production; in such cases, the nodules should not be treated. Some famous and successful singers have had untreated vocal nodules. However, in most cases nodules result in hoarseness, breathiness, loss of range, and vocal fatigue. They may be due to abuse of the speaking voice rather than the singing voice. Voice therapy always should be tried as the initial therapeutic modality and will cure the vast majority of patients even if the nodules look firm and have been present for many months or years. Even in those who eventually need surgical excision of the nodules, preoperative voice therapy is essential to prevent recurrence.

Caution must be exercised in diagnosing small nodules in patients who have been singing actively. In many singers bilateral, symmetrical soft swellings at the junction of the anterior and middle thirds of the vocal folds develop after heavy voice use. No evidence suggests that singers with such "physiologic swelling" are predisposed to development of vocal nodules. At present, the condition is generally considered to be within normal limits. The physiologic swelling usually disappears with 24 to 48 hours of rest from heavy voice use. The physician must be careful not to frighten the singer (or embarrass himself or herself) by misdiagnosing physiologic swellings as vocal nodules. Nodules carry a great stigma among singers, and the psychologic impact of the diagnosis should not be underestimated. When nodules are present, the patient should be informed with the same gentle caution used in telling a patient that he or she has a life-threatening illness.

Submucosal cysts of the vocal folds are probably also traumatic lesions that produce blockage of a mucous gland duct. They often cause contact swelling on the contralateral side and are usually initially misdiagnosed as nodules. Occasionally, they can be differentiated from nodules by stroboscovideolaryngoscopy when the mass is obviously fluid-filled. More often, they are suspected when the nodule (contact swelling) on the other vocal fold resolves with voice therapy but the mass on one vocal fold does not resolve. Cysts may also be found on one side (occasionally both sides) when surgery is performed for apparent nodules that have not resolved with voice therapy. The surgery should be performed superficially and with minimal trauma, as discussed later.

Many other structural lesions may appear on the vocal folds, of course, not all respond to nonsurgical therapy. Polyps are usually unilateral, and they often have a prominent feeding blood vessel coursing along the superior surface of the vocal fold and entering the base of the polyp. The pathogenesis of polyps cannot be proved in many cases, but the lesion is thought to be traumatic. At least some polyps start as vocal fold hemorrhages. In some cases, even sizable polyps resolve with relative voice rest and a few weeks of low-dose steroid therapy (eg, Triamcinolone 4 mg twice a day). However, most require surgical removal. If polyps are not treated, they may produce contact injury on the contralateral vocal fold. Voice therapy should be used to assure good relative voice rest and prevention of abusive behavior before and after surgery. When surgery is performed, care must be taken not to damage the leading edge of the vocal fold, especially if a laser is used, as discussed later.

Upper respiratory tract infection without laryngitis

Although mucosal irritation usually is diffuse, singers sometimes have marked nasal obstruction with little or no sore throat and a "normal" voice. If the laryngeal examination shows no abnormality, a singer with a "head cold" should be permitted to sing but advised not to try to duplicate his or her usual sound, but rather to accept the insurmountable alteration caused by the change in the supraglottic vocal tract. The decision as to whether appearing under those circumstances is advisable professionally rests with the singer and musical associates. The singer should be cautioned against throat clearing, as this is traumatic and may produce laryngitis. If a cough is present, nonnarcotic medications should be used to suppress it.

Tonsillitis

Recurrent tonsillitis in professional singers seems particularly problematic. On the one hand, no one is eager to perform tonsillectomy on an established singer; on the other hand, a singer cannot afford to be sick for a week five or six times a year. Such incapacitation is too damaging to the singer's income and reputation. In general, the same conservative approach to tonsil disease used in other patients should be applied to professional singers, and tonsillectomy should not be withheld if it is really indicated. Removing only the tonsil without damaging the surrounding tissues is particularly important to minimize restriction of palatal and pharyngeal motion by scar. A singer must be warned that tonsillectomy may alter the sound of the voice, as discussed previously.

In addition to recurrent, acute tonsillitis, halitosis caused by uncontrollable tonsillar debris may be an appropriate indication for tonsillectomy, on rare occasion. When gastric

reflux, dental disease, metabolic abnormalities, and other causes of halitosis have been ruled out and chronic tonsillitis has been established as the cause, treatment should be offered. Although we do not ordinarily consider halitosis a serious malady, it may be a major impediment to success for people who have to work closely with other people, such as singers, actors, dentists, barbers, and some physicians. If the problem cannot be cured with medication or with hygiene using a soft toothbrush or water spray to cleanse the tonsil, tonsillectomy is reasonable.

Laryngitis with serious vocal cord injury

Hemorrhage in the vocal folds and mucosal disruption are contraindications for singing. When these are observed, the therapeutic course includes strict voice rest in addition to correction of any underlying disease. Vocal fold hemorrhage in skilled singers is most common in premenstrual women who are using aspirin products. Severe hemorrhage or mucosal scarring may result in permanent alterations in vocal fold vibratory function. In rare instances, surgical intervention may be necessary. The potential gravity of these conditions must be stressed, for singers are generally reluctant to cancel an appearance. As von Leden observed, it is a pleasure to work with "people who are determined that the show must go on when everyone else is determined to goof off" (von Leden, 1978). However, patient compliance is essential when serious damage has occurred. At present, acute treatment of vocal fold hemorrhage is controversial. Most laryngologists allow the hematoma to resolve spontaneously. Because this sometimes results in an organized hematoma and scar formation requiring surgery, some physicians advocate incision along the superior edge of the vocal fold and drainage of the hematoma in selected cases. Further study is needed to determine optimal therapy.

Laryngitis without serious damage

Mild to moderate edema and erythema of the vocal cords may result from infection or from noninfectious causes. In the absence of mucosal disruption or hemorrhage, they are not absolute contraindications to voice use. Noninfectious laryngitis commonly is associated with excessive voice use in preperformance rehearsals. It may also be caused by other forms of voice abuse and by mucosal irritation produced by allergy, smoke inhalation, and other causes. Mucus stranding between the anterior and middle thirds of the vocal folds often indicates voice abuse. Laryngitis sicca is associated with dehydration, dry atmosphere, mouth breathing, and antihistamine therapy. Deficiency of lubrication causes irritation and coughing and results in mild inflammation. If no pressing professional need for performance exists, inflammatory conditions of the larynx are best treated with relative voice rest in addition to other modalities. However, in some instances singing may be permitted. The singer should be instructed to avoid all forms of irritation and to rest the voice at all times except during warm-up and performance. Corticosteroids and other medications discussed later may be helpful. If mucosal secretions are copious, low-dose antihistamine therapy may be beneficial, but it must be prescribed with caution and should generally be avoided. Copious, thin secretions are better for a singer than scant, thick secretions or excessive dryness. The singer with laryngitis must be kept well hydrated to maintain the desired character of mucosal lubrication. Psychologic support is crucial. For the physician to intercede on the singer's behalf and to convey "doctor's orders" directly to agents or theater management is often helpful. Such mitigation of exogenous stress can be highly therapeutic.

Infectious laryngitis may be caused by bacteria or viruses. Subglottic involvement frequently indicates a more severe infection, which may be difficult to control in a short period. Indiscriminate use of antibiotics must be prevented; however, when the physician is in doubt as to the cause and when a major performance is imminent, vigorous antibiotic treatment is warranted. In this circumstance, the damage caused by allowing progression of a curable condition is greater than the damage that might result from a course of therapy for an unproven microorganism while culture results are pending. When a major concert is not imminent, indications for therapy are the same as for the nonsinger.

Voice rest (absolute or relative) is an important therapeutic consideration in any case of laryngitis. When no professional commitments are pressing, a short course of absolute voice rest may be considered, as it is the safest and most conservative therapeutic intervention. This means absolute silence and communication with a writing pad. The singer must be instructed not even to whisper, as this may be an even more traumatic vocal activity than speaking softly. Whistling through the lips also requires vocalization and should not be permitted. Absolute voice rest is *necessary* only for serious vocal cord injury such as hemorrhage or mucosal disruption. Even then, it is virtually never indicated for more than 7 to 10 days. Three days is often sufficient. Some excellent laryngologists do not believe voice rest should be used at all. However, absolute voice rest for a few days may be helpful in patients with laryngitis, especially those gregarious, verbal singers who find it difficult to moderate their voice use to comply with relative voice rest instructions. In many instances, considerations of finances and reputation militate against a recommendation of voice rest. In advising performers to minimize vocal use, Punt counseled, "Don't say a single word for which you are not being paid" (1968). This admonition frequently guides the ailing singer away from preperformance conversations and backstage greetings and allows a successful series of performances. Singers also should be instructed to speak softly, as infrequently as possible, often at a slightly higher pitch than usual; to avoid excessive telephone use; and to speak with abdominal support as they would in singing. This is relative voice rest, and it is helpful in most cases. An urgent session with a speech-language pathologist is extremely helpful in providing guidelines to prevent voice abuse. Nevertheless, the singer must be aware that some risk is associated with performing with laryngitis even when singing is possible. Inflammation of the vocal folds is associated with increased capillary fragility and increased risk of vocal fold injury or hemorrhage. Many factors must be considered in determining whether a given concert is important enough to justify the potential consequences.

Steam inhalation delivers moisture and heat to the vocal folds and tracheobronchial tree and are often useful. Some people use nasal irrigations but these have little proven value. Gargling also has no proven efficacy, but it is probably harmful only if it involves loud, abusive vocalization as part of the gargling process. Ultrasonic treatments, local massage, psychotherapy, and biofeedback directed at relieving anxiety and decreasing muscle tension may be helpful adjuncts to a broader therapeutic program. However, psychotherapy and biofeedback, in particular, must be expertly supervised if used at all.

Voice lessons given by an expert teacher are invaluable. When technical dysfunction is suggested, the singer should be referred to the teacher. Even when an obvious organic abnormality is present, referral to a voice teacher is appropriate, especially for younger singers. Numerous "tricks of the trade" permit a singer to overcome some of the disabilities of mild illness safely. If a singer plans to proceed with a performance during an illness, he

or she should not cancel voice lessons as part of the relative voice rest regimen; rather, a short lesson to assure optimum technique is extremely useful.

Drugs for vocal dysfunction

When antibiotics are used to treat vocal dysfunction, high doses to achieve therapeutic blood levels rapidly are recommended and a full 7- to 10-day course should be administered. Tetracyclines may be particularly useful in managing respiratory tract infections (Panckey, 1978), as is erythromycin. Although ampicillin is used commonly, amoxicillin may achieve higher tissue levels more rapidly (Neu, 1974) and may be advantageous, particularly when therapy is instituted shortly before a performance. Starting treatment with an intramuscular injection is often helpful.

Antihistamines may be used to treat allergies. However, because they tend to cause dryness and are frequently combined with sympathomimetic or parasympatholytic agents that further reduce and thicken mucosal secretions, they may reduce lubrication to the point of producing a dry cough. This dryness may be more harmful than the allergic condition itself. Mild antihistamines in small doses should be tried between performances, but they should generally not be used immediately before performances if the singer has had no previous experience with them. Their adverse effects may be counteracted to some extent with mucolytic agents. Iodinated glycerol (Organidin) is an older mucolytic expectorant that helps liquify viscous mucous and increase the output of thin respiratory tract secretions. Entex (Baylor) is a useful expectorant and vasoconstrictor that increases and thins mucosal secretions. Humibid (Adams) is one of the most convenient and effective preparations available. These drugs are relatively harmless and may be very helpful to singers who experience thick secretions, frequent throat clearing, or "postnasal drip". Awareness of postnasal drip is often caused by secretions' being too thick rather than too plentiful.

Corticosteroids are potent antiinflammatory agents and may be helpful in managing acute inflammatory laryngitis. Although many laryngologists recommend using steroids in low doses (methylprednisolone, 10 mg), I have found higher doses for short periods more effective. Depending on the indication, dosage may be prednisolone 60 mg or dexamethasone 6 mg intramuscularly once, a similar starting dose orally tapered over 3 to 6 days. Regimens such as a dexamethasone (Decadron) or methylprednisolone (Medrol) dose pack may also be used. Care must be taken not to prescribe steroids excessively. They should be used only when vocal fold inflammation is hampering a pressing professional commitment. If any question exists that the inflammation may be of infectious origin, antibiotic coverage is recommended.

In the premenstrual period, decreased estrogen and progesterone levels are associated with altered pituitary activity. An increase in circulating antidiuretic hormone results in fluid retention in Reinke's space as well as other tissues. The fluid retention in the vocal fold during inflammation and hormonal fluid shifts is bound, not free, water (Schiff, 1978). Diuretics do not remobilize this fluid effectively and dehydrate the singer, producing decreased lubrication and thickened secretions but persistently edematous vocal folds. If they are used, their effects should be monitored closely.

Aspirin and other analgesics frequently have been prescribed for relief of minor throat and laryngeal irritations. However, the platelet dysfunction caused by aspirin predisposes to hemorrhage, especially in vocal cords traumatized by excessive voice use in cases of vocal dysfunction. Mucosal hemorrhage can be devastating to a professional voice, and singers should avoid aspirin products altogether. Acetaminophen is the best substitute, as even most common nonsteroidal antiinflammatory drugs such as ibuprofen may interfere with the clotting mechanisms. Nonsteroidal antiinflammatory drugs cause fewer bleeding problems, and acetaminophen usually does not cause abnormal bleeding. Caruso used a spray of ether and iodoform on his vocal cords when he had to sing with laryngitis. Nevertheless, the use of analgesics is extremely dangerous and should be avoided. Pain is an important protective physiologic function. Masking it risks incurring grave vocal damage that may be unrecognized until after the analgesic or anesthetic wears off. If a singer requires analgesics or topical anesthetics to alleviate laryngeal discomfort, the laryngitis is severe enough to warrant cancelling a performance. If the analgesic is for headache or some other discomfort not intimately associated with voice production, symptomatic treatment should be discouraged until singing commitments have been completed.

Diphenhydramine hydrochloride (Benadryl), 0.5% in distilled water, delivered to the larynx as a mist may be helpful for its vasoconstrictive properties, but it is also dangerous because of its analgesic effect and I do not recommend it. However, Punt has advocated this mixture and several modifications of it (1968). Other topical vasoconstrictors that do not contain analgesics may be beneficial in selected cases. Oxymetazoline hydrochloride (Afrin) is particularly helpful. Propylene glycol 5% in a physiologically balanced salt solution may be delivered by large-particle mist and can provide helpful lubrication, particularly in cases of laryngitis sicca after air travel or in dry climates. Such treatment is harmless and may also provide a beneficial placebo effect. Water or saline solution delivered via a vaporizer or steam generator is frequently effective and efficient. This therapy should be augmented by oral hydration, which is the mainstay of treatment for dehydration. A singer can monitor the state of hydration by observing urine color. Dr. Van Lawrence advises his singers to "pee pale".

Most inhalers are not recommended for use in professional voice users. Many people develop contact inflammation from sensitivity to the propellants used in many inhalers. Steroid inhalers used for prolonged periods may result in candida laryngitis. Prolonged steroid use such as is common in asthmatic individuals also appears capable of causing wasting of the vocalis muscle.

Respiratory dysfunction

Respiratory problems are especially problematic to singers and other voice professionals (Spiegel et al, 1988a). They also cause similar problems for wind instrumentalists. Support is essential to healthy voice production. The effects of severe respiratory infection are obvious and will not be enumerated. Restrictive lung disease such as that associated with obesity may impair support by decreasing lung volume and respiratory efficiency. Even mild obstructive lung disease can impair support enough to cause increased neck and tongue muscle tension and abusive voice use capable of producing vocal nodules. This scenario occurs with unrecognized asthma and may be difficult to diagnose unless suspected, because many such cases of asthma are exercise-induced. Performance is a form of exercise. Consequently, the singer will have normal pulmonary function clinically and may

even have reasonably normal pulmonary function test findings at rest in the office. He or she will also usually have good support and sing with good technique during the first portion of a performance. However, as performance exercise continues, pulmonary function decreases, effectively impairing support and resulting in abusive technique. When suspected, this entity can be confirmed through a methacholine challenge test (Cohn et al, 1991).

Treatment of the underlying pulmonary disease to restore the ability to effect correct support is essential to resolving the vocal problem. Treating asthmatic is rendered more difficult in professional voice users because of the need in some patients to avoid not only inhalers but also drugs that produce even a mild tremor that may be audible during soft singing. The cooperation of a skilled pulmonologist specializing in asthma and sensitive to the problems of performing artists is invaluable.

Speech-Language Pathology

An excellent speech-language pathologist is an invaluable asset in caring for professional voice users. However, laryngologist should recognize that, like physicians, speech pathologists have varied backgrounds and experience in treatment of voice disorders. In fact, most speech abnormality programs teach relatively little about caring for professional speakers and nothing about professional singers. Moreover, few speech pathologists in the USA have vast experience in this specialized area; and no fellowships in this specialty exist for speech pathologists. Speech pathologists often subspecialize. A person who expertly treats patients who have had strokes, stutter, have undergone laryngectomy, or have swallowing disorders will not necessarily know how to manage professional voice users optimally. The laryngologist must learn the strengths and weaknesses of the speech pathologist with whom he or she works. After identifying a speech pathologist who is interested in treating professional voice users, the laryngologist should work closely with the speech pathologist in developing the necessary expertise. Assistance may be found through laryngologists who treat large numbers of singers or through educational programs such as the Annual Voice Foundation's Symposium on Care of the Professional Voice. In general, therapy should be directed to relaxation techniques, breath control, and abdominal support (Sataloff, 1991).

Speech (voice) therapy may be helpful even when a singer has no obvious problem in the speaking voice but significant technical problems singing. Once a person has been singing for several years, a singing teacher may have difficulty convincing him or her to correct certain technical errors. Singers are much less protective of their speaking voices. Therefore, a speech pathologist may be able to teach proper support, relaxation, and voice placement in speaking rapidly. Once mastered, these techniques can be carried over fairly easily into singing through cooperation between the speech pathologist and voice teacher. This "back door" approach has been extremely useful in my experience. For the actor, coordinating speech pathology sessions with acting lessons, and especially with the training of the speaking voice provided by the actor's voice teacher or coach, is often helpful. Information that the speech pathologist, acting teacher, and singing teacher provide should be symbiotic and should not conflict. If major discrepancies exist, bad training from one of the team members should be suspected and changes should be made.

Singing Teachers

In selected cases, singing lessons may also be extremely helpful to nonsingers with voice problems. The techniques used to develop abdominal strength, breath control, laryngeal and neck muscle strength, and relaxation are very similar to those used in speech therapy. Singing lessons often expedite therapy and appear to improve the outcome in some patients.

Laryngologists who frequently care for singers are often asked to recommend a voice teacher. This may put them in an uncomfortable position, particularly if the singer is already studying someone in the community. Most physicians do not have sufficient expertise to criticize a voice teacher, and we must be extremely cautious about recommending that a singer change teachers. However, no certifying agency standardizes or assures the quality of a singing teacher. Although one may be slightly more confident of a teacher associated with a major conservatory or music school or one who is a member of the National Association of Teachers of Singing, neither of these credentials assures excellence, and many expert teachers have neither affiliation. However, with experience, a laryngologist ordinarily develops valid impressions. The physician should record the name of the voice teacher of every patient. He or she should observe whether the same kinds of voice abuse problems occur with disproportionate frequency in the pupils of any given teacher and whose pupils usually have few technical problems and are only seen for acute disease such as an upper respiratory tract infection. Technical problems can cause organic abnormalities such as nodules; therefore, any teacher who has a high incidence of nodules among his or her students should be viewed with cautious concern. The physician should be particularly wary of teachers who are reluctant to allow their students to consult a doctor. The best voice teachers usually are not reluctant to refer their students to a laryngologist if they hear anything disturbing in a student's voice. The laryngologist should write a letter to the voice teacher (with the patient's permission) describing the findings and recommendations as he or she would to a physician, speech pathologist, or any other referring professional. A laryngologist seriously interested in caring for singers should take the trouble to talk with and meet local singing teachers. Taking a lesson or two with each teacher provides enormous insight as well; taking voice lessons regularly is even more helpful. In practice, the laryngologist will usually identify a few teachers in whom he or she has particular confidence, especially for patients with voice disorders, and should not hesitate to refer singers to these colleagues, especially singers who are not already in training.

Pop singers may be particularly resistant to the suggestion of voice lessons, yet they are in a great need of training. The physician should point out that a good voice teacher can teach a pop singer how to protect and expand the voice without changing its quality or making it sound "trained" or "operatic". I find it helpful to point out that singing, like other athletic activities, requires exercise, warm-up, and coaching for anyone planning to enter the "big league" and stay there. Just as no major league baseball pitcher would play without a pitching coach and warm-up time in the bull pen, no singer should try to build a career without a singing teacher and appropriate strength and agility exercises. Physicians should also be aware of the difference between a voice teacher and a voice coach. A voice teacher trains a singer in singing technique and is essential. A voice coach is responsible for teaching songs, language, diction, style, operatic roles, and so on, but is not responsible for exercises and basic technical development of the voice.

Surgery

A detailed discussion of laryngeal surgery is beyond the scope of this chapter. However, a few points are worthy of special emphasis. Surgery for vocal nodules should be avoided whenever possible and should almost never be performed without an adequate trial of expert voice therapy, including patient compliance with therapeutic suggestions. A minimum of 6 to 12 weeks of observation should be allowed while the patient is using therapeutically modified voice techniques under the supervision of a speech pathologist and possibly a singing teacher. Proper voice use rather than voice rest (silence) is correct therapy. The surgeon should not perform surgery prematurely for vocal nodules under pressure from the patient for a "quick cure" and early return to performance. Permanent destruction of voice quality is a very real complication. Even after expert surgery, voice quality may be diminished by submucosal scarring, resulting in an adynamic segment along the vibratory margin of the vocal fold. This situation produces a hoarse voice with vocal folds that appear normal on indirect examination, although under stroboscopic light the adynamic segment is obvious. No reliable cure exists for this complication. Even large, apparently fibrotic nodules of long standing should be given a chance to resolve without surgery. In some cases the nodules remain but become asymptomatic and voice quality is normal. Stroboscopy in such patients usually reveals that the nodules are on the superior surface rather than the leading edge of the vocal folds during proper, relaxed phonation (although they may be on the contact surface and symptomatic when hyperfunctional voice technique is used and the larynx is forced down).

When surgery is indicated for vocal fold lesions, it should be limited as strictly as possible to the area of abnormality. Virtually no place exists for "vocal cord stripping" in professional voice users with benign disease. Whenever possible, an incision should be made on the superior edge of the vocal fold and the lesion should be removed submucosally and superficially to prevent scarring. This is accomplished by staying superficial to the intermediate layer of the lamina propria (Fig. 109-5). Preservation of the mucosa along the leading edge of the vocal fold may promote faster and better healing. When this is not possible, lesions such as vocal nodules should be removed to a level even with the vibratory margin rather than deeply into the submucosa. This minimizes scarring and optimizes return to good vocal function. Naturally, if concern about a serious neoplasm exists, proper treatment takes precedence over voice conservation. Surgery should be performed under microscopic control.

The use of lasers is controversial at present. Considerable anecdotal evidence suggests that healing time is longer and incidence of adynamic segment formation higher with the laser than with traditional instruments. Furthermore, two studies (Abitbol, 1984; Tapia et al, 1984) raise serious concerns about dysphonia after laser surgery. Such complications may result from using too low a wattage causing dissipation of heat deeply into the vocal fold; thus high-power density for short duration has been recommended. Nevertheless, many laryngologists caring for professional voice users avoid laser surgery in most cases pending further study. When the laser is used, a biopsy specimen should be taken for evaluation by pathologists before destroying the lesion with a laser. If a lesion is to be removed from the leading edge, the laser beam should be centered in the lesion, rather than on the vibratory margin, so that the beam does not create a divot in the vocal fold (Fig. 109-6). The CO₂ laser is particularly valuable for cauterizing isolated blood vessels responsible for recurrent hemorrhage. Such

vessels are often found at the base of a hemorrhagic polyp (Fig. 109-7). At the suggestion of Jean Abitbol, MD, Paris, France, I have placed a small piece of ice on the vocal fold immediately before and after laser use to dissipate heat and help prevent edema. No studies on the efficacy of this maneuver exist, and we need more clinical experience before drawing final conclusions, but our preliminary impression is that the ice is helpful.

Voice rest after vocal fold surgery is also controversial; although some laryngologists do not recognize its necessity at all, most physicians recommend voice rest for approximately 1 week, or until the mucosal surface has healed. Even after surgery, silence for more than 7 or 10 days is nearly never necessary and represents a real hardship for many patients.

Too often, the laryngologist is confronted with a desperate singer whose voice has been "ruined" by vocal cord surgery, recurrent or superior laryngeal nerve paralysis, trauma, or some other tragedy. Occasionally, the cause is as simple as a dislocated arytenoid that can be reduced (Sataloff et al, 1988b). However, if the problem is an adynamic segment, decreased bulk of one vocal cord after "stripping", bowing caused by superior laryngeal nerve paralysis, or some other serious complication in a mobile vocal cord, great conservatism should be exercised. None of the available surgical procedures for these conditions is consistently effective. If surgery is considered at all, the procedure and prognosis should be explained to the patient realistically and pessimistically. The patient must understand that the chances of returning the voice to professional quality are very slim and that it may be made worse. Zyderm Collagen (Xomed) injection is currently under investigation and is helpful in some of these difficult cases (Ford and Bless, 1988). However, more research will be needed to determine not only the efficacy but also the safety of this material before it can be recommended for widespread use (Spiegel et al, 1988b). Occasionally, singers inquire about surgery for pitch alteration. Such procedures (Isshiki et al, 1983) have been successful in specially selected patients (such as those undergoing sex-change surgery), but they do not consistently provide good enough voice quality to be performed on a professional voice user.

Discretion

The excitement and glamour associated with caring for a famous performer naturally tempt the physician to talk about a distinguished patient. However, this tendency must be tempered. Having it known that he or she has consulted a laryngologist, particularly for treatment of a significant voice problem, is not always in a singer's best professional interest. Famous singers and actors are ethically and legally entitled to the same confidentiality we assure for our other patients.

Voice Maintenance

Prevention of vocal dysfunction should be the goal of all professionals involved in the care of singers. Good vocal health habits should be encouraged in childhood. Screaming, particularly outdoors at athletic events, should be discouraged. Promising young singers who join choirs should be educated to compensate for the Lombard effect. The youngster interested in singing should receive enough training to prevent voice abuse and should receive enthusiastic support for singing works suitable for his or her age and voice. Singing advanced pieces and playing Metropolitan Opera star should be actively discouraged.

Training should be continued during or after puberty, and the voice should be allowed to develop naturally without pressure to perform operatic roles prematurely. Excellent regular training and practice are essential, and avoidance of irritants, particularly smoke, should be stressed early. Educating the singer with regard to hormonal and anatomic alterations that may influence the voice allows him or her to recognize and analyze voice dysfunction, compensating for it intelligently when it occurs. Cooperation among the laryngologist, speech-language pathologist, acting teacher, and singing teacher provides an optimal environment for cultivation and protection of the vocal artist.