Chapter 7: Disorders of the voice

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The relation of voice, speech and language

The human voice serves a number of communicative functions, some in connection with speech and some that are not directly related to speech and language: voice is important in several non-verbally communicated messages.

Non-language use of the voice

Many examples of non-verbal use of the voice can be observed in daily life:

(1) A baby attracting attention and inviting care from its mother. This also happens in the adult world: babies of all ages continue to use sounds for this purpose.

(2) Confirming one's identity: a boy on the beach shows himself off to family and playmates, dancing and shouting at the top of his voice. In much the same way a radio or television appearance of a popular celebrity may have more impact because people 'hear his voice' rather than because of what he has to say.

(3) The tone of the voice is more important in singing than the words.

(4) The tone of the voice expresses in attitude such as intimacy, authority, submission, dominance towards the person to whom the message is directed. The quality of the voice gives the background against which the contents of the message must be interpreted. A call of 'be careful' can convey an attitude of genuine solicitude, a reproach or a threat.

(5) The voice, even without words, can express emotions such as grief (weeping), frustration or anger (crying). When a person cries out in anger, pain, indignation or astonishment, the tone of the voice is more important than the words.

(6) The quality of the voice is related to other psychomotor means of communication, such as posture, gait, gestures and facial expressions. A person is characterized by all these psychomotor manifestations which are permanent personality traits. Moreover, they can express transient emotional states.

(7) Voice, like the other non-verbal means of expression, is partly under voluntary control. It is also part of involuntary 'body language'. The messages conveyed in an unintended way by body posture, movements, facial expression and voice play an enormous role in human interactions. The amount of non-verbal communication is grossly underestimated compared to the importance of verbal language, which is usually overrated. C'est le ton qui fait la musique (the tone makes the music) is a French expression meaning that the contents of a message depend on the way in which it is delivered.

(8) Throat and voice complaints are often non-verbal messages of emotional (psychological) disturbance. The consultant must be able to identify them as such.
If loss of voice, a sore throat or the feeling of a lump are not detected as a signal of worry or distress, the patient and the doctor both start off on the wrong foot. When both are reluctant to face the true origin of the discomfort, a psychological game develops. The patient avoids the issue by describing only his 'cold', 'feeling a lump', or 'having no voice'. The doctor avoids the danger zone by statements about 'red mucosa', 'laryngitis' and by prescribing medicine. This is more likely to happen if a more adequate assessment will cost too much time or is simply out of the range of the consultant's abilities.

Thus, even when it is absent, the voice is eloquent in its non-verbal language. Some people unfortunately are deaf to its meaning or pretend not to hear it. This is probably the most frequent cause of error in diagnosis and of failure in the treatment of voice disorders.

**Use of the voice in language**

The linguistic significance of the voice is obvious. Pairs of speech sounds such as p-b, s-z are characterized by the discriminative feature voiceless-voiced. The meaningful coding of language makes use of 'voicing' as one of the distinctive features of speech sounds (phonemes). 'Tie' differs from 'die' only with respect to voicing of the initial apico-alveolar plosive. In whispered speech the distinction is therefore harder to make.

Besides being a contributing feature to articulated speech the voice adds an element of intonation to spoken language. This is the pattern of voice-pitch in the flow of a sentence or phrase. The code for producing meaningful intonation differs in various languages and dialects. The codes apply to spoken phrases as well as to understanding a phrase, for example, the rising tone at the end of a phrase when a question is intended. Obviously the listener must attach the same meaning to a code as the speaker has intended to convey. The intonation or prosody aspect suffers when a voice is very weak or is out of control in any other way. Monotonous speech or unusual intonation of accents is prevalent in neurological voice and speech disorders.

The emotional expression of the voice can sometimes be understood across language barriers, just like the meaning of certain gestures is understood by all mankind. Speech, on the contrary, is only understood by those who are familiar with the particular language environment in which the speaker has grown up. Summing up, it can be said that voice is a natural medium well adapted to communicate emotional content, whereas speech is a cultural medium that is suitable to convey intellectual content. Speech may be used to express feelings but also to hide, disguise or deny them.

**Anatomy and physiology of voice control**

For clarity, the phonatory system can be divided into three levels and a control function:

1. the voice activating air-stream (the respiratory system);

2. the voice generator (the larynx with its vocal folds) which causes the air to vibrate and thus produces the tone;
(3) the voice resonator (the pharyngeal and oral cavity) which selectively transmits some frequency bands (called formants) and weakens others (antiresonances);

(4) the coordinating and controlling function (the central and peripheral nervous system).

The voice activating air stream

During phonation there is a difference in air pressure below and above the glottis. This pressure difference provides the energy that overcomes the resistance of the adducted cords, and causes them to vibrate. In efficient use of the speaking voice the pressure drop is small (the equivalent of 5-10 cm of water pressure) and the air flow is also low (less than 200 mL of air/s). A speaker or singer can learn to exert control over the subglottic pressure, the degree of glottal closure, and the flow of air. These three parameters are, of course, mutually dependent. Too weak closure of the glottis causes a high flow, sometimes audible as a breathy voice with a rush of air. Too strong glottis closure accompanies a high pressure or a low flow, or both. This is audible as a hyperkinetic or croaking voice.

Patterns of breathing

At the end of an expiration when the muscles of the thorax and the abdomen relax, there is a short pause before the onset of inspiration. This is called the expiratory pause. It occurs only when the body and the mind are completely at rest. Under this condition the organism has a low rate of oxygen and carbon dioxide exchange and is not expecting an approaching effort or excitement. The respiratory frequency is low and the displaced volume of air is small. Slight contractions of the diaphragm suffice to meet the demand for air. The only respiratory movements that can be seen are movements of the abdominal wall as it is displaced outward by the descent of the diaphragm.

The respiration at rest as just described can change into a more active form as a consequence of:

(1) physiological adjustment to increase CO₂ production in the tissues when metabolism increases;

(2) emotional anticipation preparing the organism for action. The latter can also occur as a poorly adapted conditioned anxiety response. When it is not followed by increased activity it can lead to neurotic hyperventilation.

Normally the first visible sign of deeper breathing is the outward movement of the flanks that is added to the forward movement of the abdomen. When the large pillars of the diaphragm contract, the dome of the diaphragm is flattened and the lower ribs are pushed outwards. The flanks can also be expanded by active contraction of the external intercostal muscles. This happens when the need for air increases and breathing becomes deeper. Elevation of the ribs widens the lower thoracic aperture increasing the diameter of the thorax; it also assists the movement of the diaphragm to displace more air.
Another very effective inspiratory movement is stretching of the curved vertebral column: when a cervical and lumbar lordosis and a thoracic kyphosis are straightened, the volume of both the abdomen and the thorax is increased. Part of the voice therapy repertoire is correction of body posture: establishing contact with the ground by planting the feet firmly and cancelling a lumbar lordosis by tilting the pelvis backwards. This increases the distance between the insertions of the diaphragm and increases the range of contraction of that powerful muscle.

Generally speaking, the respiratory pattern mounts from abdominal to thoracic and accessory respiratory musculature with increasing alertness or arousal. Strong emotions can give rise to overbreathing. They prepare the body for action by autonomic and endocrine changes, and when the anticipated action is put off (for example, by fear of its consequences) and the hyperventilation continues, too much CO₂ will be washed out of the system. A low CO₂ level in the blood and the tissues thwarts the availability of calcium ions and this can cause various problems. In its acute form it can lead to a regulatory deficit of the circulation and to fainting (collapsing is in itself an extreme withdrawal and flight response; see voice reactions to stress). In a less acute form nervous overbreathing can cause symptoms of the so-called hyperventilation syndrome: lightness in the head, dizziness, headache, irritability, paraesthesia (a tingling feeling in the extremities), muscular spasm of the hands and the face. Hyperventilation is a regular occurrence in voice pathology, for example, in functional dysphonia, when the patient speaks all day long with a great waste of air and in organic paralytic dysphonia, when the patient is unable to close the glottis as a result of vocal cord paralysis on both sides.

Effect of insufficient control of the airflow on the voice

A well-controlled voice is produced by relaxed and supple cords caused to vibrate by a moderate stream of air under low pressure. In vocal dysfunction the air pressure and the airstream are not well controlled during phonation: the vocal cords will not be closed fully during phonation and will allow passage to a large airflow. This is observed in indirect laryngoscopy as an oval or triangular glottic opening. It is incorrect to interpret such an image when seen with a laryngoscopic mirror as a paresis of the internal arytenoid muscles: after some instruction for improved voice production the cords are seen to close perfectly, which indicates that the paresis has no organic origin. Incomplete closure of the glottis is often seen when the intrinsic laryngeal musculature is in a state of excessive tension that is inappropriate for effective function. Under laryngostroboscopic observation the vocal folds do not vibrate over their full width; the resulting sound lacks resonance as a consequence of a lack of overtones.

When focal dysfunction is caused by vocal fold closure not being in tune with breath control it is customary to speak of hyperfunction in the case of excessive closure of the glottis and of hypofunction in the case of insufficient closure. In both conditions there is a lack of breath support. This notion is important for voice therapy. It explains how excessive airflow is kept in check during phonation.
Breath support

In respiration at complete rest the expiratory phase is caused entirely by the elastic force of lung tissue that has been stretched during the inspiration and that resumes its neutral position. No extra muscular force is needed to drive the air out, so long as the neutral starting point is not reached.

After a deep inspiration (when preparing to speak or to sign a long phrase) the elastic expiratory force is rather large as a result of the strongly distended condition of the lungs. If this force were allowed to drive the air out through the adducted vocal folds the air pressure would be greatly in excess of that required for good phonation. Therefore the excess pressure and flow are checked by a counter/inspiratory force:

(1) the weight of the abdominal contents, when the individual is standing upright;

(2) a certain tone of the inspiratory musculature - the diaphragm and the external intercostal muscles. The checking activity is strongest at the beginning of phonation and can diminish gradually as the expiration progresses and the stretched tissues approach their natural starting position. When all complementary air has been spent the expiratory muscles may enter into play to drive out the reserve volume of air (Mead, Bouhuys and Proctor, 1968).

The inspiratory 'rein' during phonatory exhalation is called breath support. Most professional speakers and singers are well aware of some form of indirect control of the resonant properties of their voice. Some feel it in the abdomen, others in the sides or the back. Some report that the back of the neck feels like a powerful control centre for the quality of their voice. The following paragraphs explain how the curvature of the neck affects the length and tension of the vocal cords.

The vibrating glottis: the voice generator

The expiratory airstream brings the vocal folds into vibration. The impressive range of intensities, tonal qualities and pitch of the human voice is the result of:

(1) the movements in the cricothyroid articulations which stretch or shorten the vocal ligaments;

(2) the movements of the arytenoid cartilages, each of which is in the centre of intrinsic laryngeal muscles which cause them to rotate and glide over the articulatory surface of the cricoid cartilage;

(3) the tendinous membrane that covers the inner surface of the intrinsic musculature of the vocal folds. It inserts on the inner side of the cricoid and ends on the free margin of the vocal ligament. This membrane has also been called the conus elasticus or the cricovocal membrane.

The coordinated activity of the intrinsic laryngeal muscles causes the vocal folds to take on a firmness, a certain length and a degree of closure (firmly or loosely adducted folds during the production of voice sound). When close together the vocal folds narrow the airway
- the site is called the glottis. The folds act like a fluttering valve: they are alternately pushed apart by air pressure and sucked together by airstream. The vibratory cycle (consisting of an open and a closed phase) repeats itself in a rapid succession of 80-800 cycles (or more) per second. The closing phase is caused by the Bernoulli effect. When the air speed in the narrowing between the folds is at its highest, the pressure exerted on the walls of the glottis is minimal, giving rise to an abrupt closure. It is this shock wave which, in the frequency of the glottal tone, excites the resonating cavity in rapid succession. The more abrupt or steep the wave, the more harmonic overtones are generated.

In contrast with the chest register, which is the normal mode of vibration for the male speaking voice, the production of a falsetto voice is entirely different. Here the vocal ligaments are stretched to their full length. The thyroarytenoid muscles in the vocal folds are fully relaxed and do not resist the stretching of the vocal cords. The vibrating mass is reduced to the medial rim of the vocal folds because of the tension in the ligaments. Also the folds are not completely closed as a rule; consequently the flow of air is interrupted in a less abrupt way than was the case in chest voice. The resulting pressure wave is smoother and gives rise to only one or two harmonic overtones, which gives the voice a flute-like character.

The suspension of the larynx

The way in which people use their voice is largely governed by habit. Although phonatory behaviour is in principle a voluntary activity, it is in part automatic and therefore hard to change. Most of the voice disorders that are seen in the clinic stem from a faulty use of the voice. Changing voice habits is therefore the most important therapy in this chapter on voice disorders. In order to understand how a patient can, with the guidance of a therapist, attain a better control of his voice technique and how this is achieved, the inside of the larynx, and its suspension system must be described. This will enable us to see how the voice generator is linked to the respiratory system. Also the properties of the generator in relation to the volume and shape of the resonating cavities will become clearer.

Because of the firm connection of the larynx to the hyoid bone these structures can be considered as one complex suspended between the base of the skull and the upper aperture of the thorax. It can be moved up and down in front of the cervical vertebrae by long muscles such as the stylohyoid, omohyoid and geniohyoid muscles. From the highest position, as in swallowing, to the lowest, as in yawning, the larynx remains securely fastened to the vertebral column by an ingenious suspension system on which the larynx glides like a sledge over the vertebrae. The carriage consists of a tendinous centre that is held by the constrictor muscles. It extends from the hyoid to the cricoid, and slides over the periosteum in front of the vertebral column. Short muscles - the middle and lower pharyngeal constrictor muscles, the most caudal of which is the cricopharyngeus muscle - connect the larynx and hyoid to the tendinous sheet. The lower of these muscles has a particular significance in voice control. When the larynx is in a low position it tilts the cricoid forward, thus shortening the vocal folds (detente of the ligament). Together with its antagonist, the cricothyroidus, it controls the delicate balance of vocal cord tension. If the larynx-hyoid complex is held in an elevated position, the direction in which the contracting cricopharyngeus pulls is changed - it will pull in a horizontal or even caudal (downward) direction, and tilt the cricoid backwards. Its effect is then parallel to that of the cricothyroidus and results in stretching of the vocal ligament. This effect of elevating the larynx is observed in people without vocal training who try to
reach high notes when singing or crying. The result is a shrill and thin high tone, because the manoeuvre, apart from stretching the vocal cords, reduces the length of the vocal tract and diminishes the volume of the resonator.

**Influence of respiratory tract on voice generator**

How the muscles immediately related to the larynx and the hyoid affect the length and tension of the vocal cords has been described previously. More distant forces also influence the shape of the glottis and the consistency of the vocal folds. The effect of the contracting diaphragm on the length of the vocal cords is discussed next. When the diaphragm contracts during inspiration, it moves downwards and pulls the bronchial tree with it. The caudally directed force of the trachea (which according to Zenker and Zenker (1960) can be in the order of 1000 g) pulls the anterior part of the cricoid downwards. The anterior part is moved because the main force is applied anterior to the cricothyroid joint, situated on the posterior half of the cricoid. The cricoid is thus tilted forward by the inspiratory force of the diaphragm, and the vocal folds are shortened.

The tracheal pull is maximal when the diaphragm is in the full inspiratory position and when the thorax is wide with expanded and elevated ribs. In this ready-for-phonation position, the external frame in which the larynx is suspended provides complete freedom for the finest adjustment by the intrinsic laryngeal musculature. Messchaert, a great Dutch baritone, described the singer beginning a tone with his chest full of inspired air as feeling that he is, like the tone, light and floating on air.

Understanding the control of the glottis by muscle forces near and far is important for the diagnosis of voice dysfunctions. It has yet another application. Patients who have a bilateral recurrent nerve paralysis with the cords in a paramedian position suffer dyspnoea as a result of high air resistance of the glottis during inspiration. When they stick out the tongue they elevate the hyoid-larynx complex. If, at the same time, they apply abdominal breathing with a well descended diaphragm the vocal folds will be passively abducted (Zenker and Zenker, 1960). Even though the widening of the glottis may be slight, it has been sufficient to help some patients through a difficult period without having to resort to tracheostomy.

**The oropharyngeal cavity: the voice resonator**

When tracheal pull is applied during the inspiratory activity of the diaphragm, it can be combined with contraction of the pretracheal muscles. The effect is one of widening and lengthening of the lower pharynx and this has a considerable effect on the voice sound. When the volume of the pharyngeal cavity increases, lower harmonics are selected from the sound spectrum generated by the vocal fold vibrations. The transmission of lower harmonics is perceived as a full and dark sound. This is called covering of the voice, as contrasted with the open voice.

In producing an open voice the larynx is held in an elevated position (short resonator) and the vowels have a clear ai-like quality as opposed to the dark o-like quality in covered voice.
Untrained singers have a habit of moving the larynx upwards when they attempt to reach high notes. Trained singers, on the contrary, maintain the larynx at practically the same level throughout the entire range of their voice. The covering mechanism is as it were contained within the mechanism for higher pitch. By gradually mixing the colours of the voice registers they avoid any gap or sudden transition between registers. This is attained by keeping the volume of the resonator fairly constant, and by allowing the vibrating mass of the folds to decrease gradually, not suddenly as in transition to the falsetto mode.

Three parts of the oropharyngeal resonator are of special interest: the laryngeal entrance immediately above the glottis; the middle part with the velopharyngeal valve; and the outermost part between the lips. The steep waves of air pressure that emanate from the glottis do not flow out into a wide pharynx immediately, but have to pass the narrowing between the ventricular folds. A rather strong closing of the ventricular folds has been observed especially during the production of clear ringing tones. The situation is not unlike that in the bell-shaped cup of a trombone or other brass instrument. The shock waves are funnelled into a narrow enclosure and thereby reach high pressures than if they had not met this resistance. The ventricles and the interventricular space act as a transformer or a filter of the primary glottic sound which can be modified, for example, by raising or lowering the larynx.

The consistency of the walls of the resonator is important. Firm walls transmit the sound without loss of high frequency components, whereas soft walls absorb parts of the sound energy spectrum. The soft palate or velar valve is a 'soft spot' that can be varied at will. When the velum is firmly closed and the velar musculature firmly contracted, transmission is complete and the sound issuing from the mouth is clear. When the musculature is relaxed or thin (in the case of a congenital insufficiency) a part of the spectrum is filtered out and absorbed by the soft spot. It is not even necessary for the velar porch to be open; when an area as large as that of the soft palate is soft, it works as a filter: low frequencies are comparatively unaffected, frequencies above 1200 Hz disappear from the spectrum. The result is perceived as a hypernasal sound that lacks lustre.

The voice sound generated at the glottal source and transmitted through the resonating tube is finally imparted to the ambient air through the mouth. The vocal intensity (as measured) or the loudness (as perceived) are roughly proportional to the area of the mouth opening. This explains the importance of practising mandibular opening in singing and speaking.

**Integration and control by the central nervous system**

When a person is actively engaged in oral communication, be in song or speech, the entire body participates in the activity. Not only the intrinsic laryngeal musculature, but also the soft palate, the tongue, the floor of the mouth, the muscles of the neck, the diaphragm, the trunk and the pelvis (for breath support) all take part in expressive phonation. All this is controlled by the central nervous system. Signals arrive at the central nervous system carrying information about the condition of stretch of muscles and ligaments, the position of joints (static signals) and the changes that take place during movement (dynamic signals). Other afferent signals arrive from internal organs such as the mucosal surfaces of the respiratory
tract (Wyke, 1973). The central nervous system integrates the information and sends out signals for the necessary adjustment of muscular tone.

The key to voice therapy is to teach a patient voluntary control over involuntary behaviour. It is therefore important to realize that at the top of the hierarchy, governing the entire process of phonation, is not the central nervous system, but the individual himself. This point of view is sometimes neglected by those whose attention is more narrowly focused on the mechanism of the voice. A patient can normally be held responsible for his use of the voice. If he has temporarily lost control of his voice it is usually as a consequence of some form of stress in facing his environment. Stress is usually not a result of a vocal disorder, but the cause of it. Stress is translated into psychomotor disturbances that affect posture, respiration and voice control. This in turn gives rise to organic changes of the folds caused by faulty use or overloading of the vocal folds.

The examination of patients with voice disorders

History

When taking the history in the case of a voice disorder, the principal complaint is elicited first, in the patient's own words. It is supplemented by questions on the following points: the date of onset (gradual or abrupt), the course, previous treatments; what was the voice like before the trouble began; have there been earlier similar troubles; which activities in the patient's job or free time put demands on the voice? In a complete history all the remaining relevant data required for the diagnosis are assembled. At the very least the following are enquired for the diagnosis are assembled. At the very least the following are enquired about: general health and life-appreciation, respiratory and digestive tracts, cranial nerves (swallowing, hypernasality) and, most important, relationships in the family, at school or in the patient's job. Sataloff (1981, 1984) has summed up points of relevance in the history and examination of professional singers.

Examination

The examination begins during the history taking. An impression is gained of the patient as a communicator by his conduct, facial expressions and eye contact. The opportunity is taken to listen to the sound of the voice and to note its peculiarities. For comparison at a later visit the qualities of the voice should be recorded. A language has to be developed for this purpose, the following metaphors are more or less descriptive. Is the voice:

| low       | or | high      |
| loud      | or | soft      |
| powerful  | or | weak      |
| clear     | or | hoarse, husky |
| sharp     | or | dull      |
| sonorous  | or | thin      |
| resonant  | or | falsetto  |
| periodic  | or | raw, harsh|
| relaxed  | or | tense, pinched. |
It is usual to include in the description an interpretation of the manner of voice production, for example:

hyperkinetic, that is a tense voice with forceful closure of the glottis and high subglottic air pressure;

hypokinetic, that is a voice with little energy, and with air waste.

The posture of the body is noted - tense, relaxed or slouched - and the breathing habit - quiet movements of the abdominal wall or high thoracic breathing, using the accessory muscles of respiration.

**Functional assessment**

Assessing the voice function by eliciting various kinds of voice production is important. Often the crucial point in phoniatric diagnosis is deciding how far the functional capabilities of the voice go, and to what degree they are limited by an organic factor. Taking a phonetogram is a thorough way of eliciting a large variation of voice sounds. As a preliminary examination, the way in which the patient's voice alter in response to the following instructions is observed: coughing, phonating while yawning (check whether the larynx is held in a really low position), voice production successively with a relaxed sigh, with a falsetto voice, and in the case of hypofunction during an attempt to produce a sharp, piercing voice. In this way the functional potential of the organ, the extent to which the patient can control his voice, and his readiness or resistance to change his voice can be quickly assessed.

The function of the voice is also evaluated during the examination of the ear, nose and throat. The patient's attention is then distracted from the performance of his own voice. The oral cavity and the pharynx are inspected, and the length of the velum is noted in relation to the depth of the pharyngeal isthmus. The air conductance of both sides of the nose is tested by alternately closing off one of the nasal orifices, the neck is inspected and palpated and indirect laryngoscopy performed.

**Indirect laryngoscopy**

During indirect laryngoscopy the vocal cords are observed in quiet and deep breathing and while performing the following manoeuvres: producing a low voice, coughing with a short dry cough, producing a high falsetto and a sharp loud voice. Thus, an impression is gained of the motor capabilities of the larynx, and the value of an isolated abnormal phenomenon is reduced to its proper proportion. For example, if the vocal cords do not close completely during phonation, but do close completely on coughing and phonating in a harsh voice, one can conclude that closure of the glottis is possible, that the incomplete closure is of functional (habitual) origin. The result of the inspection is described and illustrated with a simple drawing. An estimate of the length is made and noted (long, short, or cords of average length).
The observed findings are then summed up in a conclusion which relates them to each other and ascribes them to their probable cause(s) - the diagnosis. A phoniatic diagnosis has to account for:

(1) the condition of the vocal folds;
(2) capabilities and limitations of voice function;
(3) contributing factors of constitution and temperament;
(4) factors maintaining the dysfunction: psychological, habitual and environmental factors.

Finally, the diagnosis is discussed with the patient and advice formulated. Whether the choice of therapy be medical, surgical or behavioural, the patient should be helped to make a decision for himself based on the available information. The motivation to begin the treatment determines in part a successful outcome, particularly when the patient is referred for psychotherapy or voice therapy. The referring specialist can influence that motivation.

In most patients it will be possible to arrive at a decision with the method of examination just described. Further instrumental techniques can only supply superfluous information in most cases. They should be omitted from the routine examination, lest they should give the patient a wrong impression that he has a more serious disorder than is actually the case. If the examiner wishes to collect data for scientific reasons, he should tell the patient, and ask his permission. It is morally and ethically wrong to subject the unknowing patient to all sorts of recordings that benefit science and industry more than the patient. With this restriction, some further methods of examination can be used in particular cases.

**Special methods of examination**

**Magnetic tape recording of the voice**

Recording the voice has several advantages (Yanagisawa, Casuccio and Suzuki, 1981; Gould, 1983):

(1) it provides a document for later comparison;

(2) when replayed the examiner can focus all his attention on features of the voice and articulation, and on characteristics in the use of language, without having his attention distracted by conducting conversation;

(3) when replaying the recording in the presence of the patient some features can be discussed which make the patient aware of the nature of the dysfunction and motivate him to accept treatment; at the same time the examiner obtains an idea about the patient's ability to discriminate between the abnormal and desirable qualities of the voice, which is important in prognosis;
(4) the recording allows various forms of acoustic analyses without further burden to the patient.

The phonetogram

The examiner's subjective assessment of the loudness, pitch and quality of the voice can be supplemented by objective measurements. There are user-friendly but costly apparatus on the market that combine a number of acoustic measurements and calculations. A simple sound-intensity meter and a musical instrument which can produce a series of tones in the range between 60 and 1400 Hz will suffice for the examiner with a musical ear. The sound intensity and the pitch can be plotted against each other in a graph, which then shows clearly the range of the voice and its intensity span for all frequencies that have been tested.

The voice quality or timbre is harder to quantify. Attempts to derive a representative index for voice quality from the acoustic signal will yield results in the near future.

In clinical judgement of voice dysfunction data from many sources are combined. One of these sources is laryngostroboscopy.

Stroboscopy

Mirror examination of the vocal folds under intermittent light is an excellent clinical tool for observing details of the epithelium and the deeper structures during phonation. The vibratory motion itself and the different phases of opening and closure of the vocal folds can be seen.

The action of the laryngostroboscope rests on the fact that the vibrations of the vocal cords are periodic, so that the vocal cords return at regular intervals to the same position. If the vocal cords are illuminated in exactly the same phase of vibration by a short burst of light they appear to be standing still. Because of the speed with which the flashes of light follow each other, and because of the afterimage effect of the eyes the vocal cords appear to be stationary. A microfilm signal ensures synchronization of the flashes of light with the vibrations of the vocal cord. A delayed image of the vibrations is produced by slightly reducing the frequency of the flashes of light compared with the vibrations of the vocal cord. The vocal cords are then illuminated in a successively later and later phase of movement by the pulses of light. For a description of the technique the reader is referred to Kitzing (1985).

Stroboscopic examination of the vocal folds is carried out in the same manner as conventional laryngoscopy, using a forehead mirror with an observation hole and a laryngeal mirror. However, the normal light source is replaced by the flashing xenon-tube. An optical system is used for video display and recording of the image and the light is transmitted from the source to the pharynx by a quartz fibre bundle. Mainly the upper surface of the vocal cords is seen, whereas the lower surface remains out of sight. However, the medial surfaces which are directed towards each other are easily seen, at least during the open phase of the vibration. This is an advantage over conventional laryngoscopy in which the fast vibrations during phonation only allow a blurred view of the medial edges. Small irregularities can then escape the examiner. In stroboscopy it is possible to see accurately where an epithelial abnormality is situated and how it participates in, or impedes, the phonation. In stroboscopic
laryngoscopy the vibrating part of the vocal folds is sharply defined, and everything which protrudes from their medial surfaces is distinctly observed.

With the help of a well adjusted stroboscope the extremely fast vibratory movement appears as a gentle waving motion.

**The pattern of the wave motion**

In chest or modal register the vocal folds have a soft or elastic consistency. A wave edge appears from the underside, moving the medial surfaces apart. It ebbs away when it reaches the upper surface of the folds. At the same moment the glottic chink has already begun to close from the underside. In the lower tones of the vocal range the folds are soft, and the amplitude of vibration is large. As the pitch is increased the substance of the folds becomes gradually firmer, and the amplitude of vibration smaller. In untrained voices there is a sudden transition towards the falsetto register.

**Diagnosis and treatment**

**Synoptic diagram**

*Table 7.1* displays the various voice disorders. It is divided into four columns: the right columns shows the disorders or primarily organic origin, such as laryngeal paralysis and papilloma. The left column shows the psychogenic and habitual voice disorders; there is no laryngeal pathology, and from an organic point of view the phonatory system is capable of function. The cause of dysfunction is either emotional or habitual. In the former case the voice is inhibited by psychological stress, in the latter case faulty use or overloading of the voice causes the dysfunction. Functional dysphonia of long standing may give rise to organic adaptations to the misuse.

These secondary organic affections of the vocal cords are displayed in the middle columns. These are the consequences of temporary or chronic abuse of the vocal cords and, so long as they have not progressed too far, are still reversible. For this reason they belong to the large class of functional dysphonias, and not to the primary organic dysphonias.

**Psychogenic voice disorders**

Emotionally-conditioned voice disorders are by no means rare and they often demand skilful and time-consuming professional assistance before the patient can resume control over his voice. The voice is the mirror of the soul and in these cases the loss of control of the voice shows the soul to be in disarray. A questionable form of therapy still often used by otolaryngologists consists of suggestive laryngological actions executed with magic and/or authority. If the loss of voice has allowed the patient sufficient time to re-establish mental composure, a suggestive treatment may be appropriate. However, the chances for recurrence are high if the causes of the stress and the resulting disarray are left untreated. In such cases the needs of the patient are best answered by an appropriate form of counselling, for which the patient can be referred to the family physician, a knowledgeable speech therapist or, if applicable a priest. Every specialist should be aware of his limitations; if a laryngologist feels
that he is inexperienced in counselling patients in emotional turmoil, he should help the patient to find a suitable source for moral support.

In a number of cases the pseudoparalysis is the consequence of a lack of assertiveness. A person who knows how to hold his own in difficult circumstances is less vulnerable to psychogenic dysfunctions than a person who lacks self-reliance. A course in assertiveness training can provide immunization to episodes of aphonia and prevent recurrences.

Table 7.1 Overview of voice disorders

<table>
<thead>
<tr>
<th>Functional</th>
<th>Organic</th>
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</thead>
<tbody>
<tr>
<td>Psychogenic (phononeurosis)</td>
<td>Habitual</td>
</tr>
<tr>
<td>Secondary organic (phonoponosis)</td>
<td>Primary organic</td>
</tr>
</tbody>
</table>

Emotional or psychotraumatic interference with voice control

Improper use of the voice (habitual dysphonia) leads to -->

Overloading, leading to abnormal adaptations of the cords such as:

- Congenital web or asymmetry

Anxiety neurosis
Neuromotor disorders (peripheral or central)

Compensation neurosis (reinforced by the effect)

- Habitual dysphonia -->
  - Irritation of the mucosa, recurrent laryngitis
  - Trauma (also surgical and intubation granuloma)

Psychogenic aphonia or dysphonia

Hypofunction -->

- Oedema, nodules (chronic nodular laryngitis)
  - Cysts, polyps, infections:
    - common cold, tracheobronchitis, syphilis, systemic diseases

Spastic dysphonia

Hyperfunction -->

- Chronic laryngitis with hyperplasia of epithelium: leucoplakia, pachydermia (contact ulcer)

Disorders related to the mutation

Prolonged mutation
Mutation falsetto

Incomplete mutation -->

- Hypoplasia of muscular and connective tissue
  - Tumour benign/malignant
  - Endocrine disorders
  - Congenital weakness (sulcus glottidis).
Voice reactions to stress

A common reaction to frustration and grief is crying. This behaviour can be described as 'agonistic', that is a response to a situation that the individual is incapable of coping with in a more adult way. He or she then resorts to a primitive behavioural pattern of withdrawal or flight: crying solicits pity and help from bystanders, appeases a threatening dominant person and is one way to solve an unbearable situation.

Even more common than crying is responding to frustration and anger by shouting. Both weeping and becoming angry belong to the same family of agonistic behaviours. In contrast to crying which is linked to flight and submission, shouting in anger is linked to fight and aggression.

Shouting and crying are generally felt as socially undesirable or even unacceptable. Many people have been so conditioned by their upbringing that they reject consistently any show of emotions. Such an attitude can easily lead to repression of emotions and inhibition of vocal expression of feelings. The trouble that led to these feelings thus has a minimal chance to be solved, and the source of stress continues to demand attention.

In this vicious circle of bottled-up feelings and unsolved displeasures, conversion symptoms may develop. The whispering voice of psychogenic aphonia is one example. It is of the submissive 'flight' type; hypokinesia prevails and it is prevalent in women. Another form more prevalent in men is vocal stuttering, also called spastic dysphonia. It is a sometimes querulous, sometimes aggressively protesting form of speech with hyperkinetic characteristics. It can have a gradual onset in which the patient feels slight irritation or involuntary contractions in his throat. These eventually give rise to scarcely perceptible interruptions of the voice in the middle of a word, or to an irregular tremor during voiced sounds. As the stress does not improve and the voice disorder only makes it worse, the patient starts a new vicious circle of his own design and possibly with the help of his therapist or consultant.

In his forceful attempts to cope with the vocal inhibitions and interruptions, the patient will strain to push the sound out. New symptoms are added, and the disorder may worsen, as can happen in developmental stuttering: the inadequate attempts to avoid or to overcome the difficulties cause even more secondary symptoms.

The diagnosis is difficult (Stoicheff, 1983). The early stage of spastic dysphonia can be similar to dysarthric voice complaints as seen in degenerative disease of the motor system (amyotrophic lateral sclerosis, multiple sclerosis). Their course is different. The voice dysfunction will persist only if the communicative stress is not solved and the patient's coping abilities are not improved. However, a neurological degeneration will show deterioration over months or years. In case of doubt an audiometric brainstem evoked response will discover an organic process. In the author's cases of spastic dysphonia of psychogenic origin, the audiometric brainstem evoked response has always been normal. A better term would be pseudospastic dysfunction from the spastic dysarthric voice dysfunctions caused by medullary and brain disease.
Guidelines for the treatment of psychogenic dysphonia

(1) Help the patient find out what may have caused him to lose control of his voice.

(2) Assist him/her to clear up misinterpretations of the complaint in the home and family environment. It is better to admit emotional stress as the cause of the voice suffering than to continue the game of 'laryngitis' or 'neurological disorder'.

(3) Prevent unnecessary diagnostic examination, which draws attention to the conversion symptom, promotes somatic fixation, and leads the attention away from the emotional inadequacies which have caused it.

(4) If the events and circumstances that caused the emotional stress have been discovered, the patient should receive support and instruction on how to cope with similar stressful events.

(5) If patients cannot summon up the courage to look into the emotional causes of the failure of their voice function, they need a strengthening of their self-reliance and training of their personal resiliency.

When the person's coping ability is improved, rather than treating the symptom, the symptom will soon disappear by itself.

Habitual dysphonia

When a person in normal circumstances nearly always uses a poor voice, this is termed habitual dysphonia. The quality of the voice has no relation with stressful events and seems to be a habit. Just like an emotionally-conditioned dysphonia it is a learned behaviour which can be changed. However, there are differences. For the correct diagnosis the consultant should obtain answers to several questions. If the following series is answered in the affirmative, the complaint is probably a habitual dysphonia:

(1) has the quality of the voice always been poor?
(2) has the voice problem had a very gradual onset?
(3) is the quality of the voice nearly constant?
(4) has the voice failed repeated after prolonged speaking?

If the following questions are answered with 'yes' the diagnosis is more likely to be psychogenic dysphonia:

(1) before the voice problems began was the voice quality good?
(2) has the change in voice quality arisen abruptly?
(3) is the quality of the voice inconstant, changing with the circumstances?
(4) has the voice failed repeatedly in situations of emotional stress?

There is no sharp division between habitual and psychogenic voice disorders. Anyone can suffer a temporary loss of control of the voice as a result of stressful circumstances, and people with poor voice habits are probably more vulnerable than others.
Perello (1962) has expressed this idea by assigning patients with functional voice disorders a place on the following scale:

phononeurosis and phonoponosis

<------------------------------------------------------------------------------------------------->

emotional problem misuse and overloading

Diagnostic analysis can determine the extent to which emotional factors, voice use and voice load are responsible in an individual case. A combination of these factors was indicated by an old term 'phonasthenia'. A typical example was the teacher with a poor voice technique, who loses his voice in the course of the day owing to emotional stress in his occupation. Instead of abiding by this ill-defined term, the therapist should see clearly whether he is working on improving the patient's voice technique and, when he is, bracing weaknesses of personality and improving the patient's skill in communicating with the environment. The two approaches can be applied in combination by the same therapist.

Some patients need exercises and very little counselling. Others are cured by a few counselling sessions and no voice practice at all.

Disorders of the voice in relation to the mutation

The voice changes at the start of adolescence, when a boy is between 12 and 15 years of age. A low voice, divided into a chest and a falsetto register is one of the sex characteristics of the human male. It is a result of the growth of the larynx and the vocal folds under the influence of testosterone. Increased production of testosterone by the testicles is in turn initiated by the decrease in gonadotrophis, secreted by the hypophysis. The voice change begins a short time before the growth of the larynx becomes noticeable. After about a year the speaking voice has fallen on the average eight semitones (from around 268 Hz to 173 Hz). These are average values but there are great individual variations. The mutation is not only a change of the tonal range but is especially a change of the sound quality: the light boy's voice gives way to the heavy man's voice.

The popular association of functional mutation disorders with feminity or sexual immaturity is incorrect: cases of intersex and eunuchoidism are extremely rare. They will be mentioned in the section on primarily organic voice disorders. In order to ascertain that a patient is developing normally, the first question can be whether he has started to shave. Some hair under the nose and on the chin and the presence of acne are reliable indications of androgenic hormonal activity. A prominent junction of the thyroid alae (the Adam's apple) indicates sexual maturation of the larynx. If laryngoscopy shows vocal cords of normal length this is another sign that the voice disorder under investigation is not of hypogonadal origin.

The above applies to all three of the common mutational disorders: prolonged mutation, mutation falsetto voice and incomplete mutation. All three are abnormal functional adjustments to the change in size of the vocal folds. The audible characteristics in each are different. In prolonged mutation the heavy and the light register alternate. For every part of a sentence that is spoken in falsetto voice there are a few syllables or words spoken in the chest voice. Sometimes the young man is not aware of the inconsistency in timbre and pitch of his voice which may be one reason why has not achieved control over his new voice.
Inconstancy of the voice also occurs in normal cases of mutation; it is only when the duration extends over 6 months or so and does not show a tendency to decrease, that it is termed a prolonged mutation.

A person with a mutation falsetto voice speaks continuously in a falsetto voice. There may be brief periods, for example during laughing or coughing when the voice drops into a heavy register. This event greatly facilitates the diagnosis because only a mature male larynx can generate separate registers. Hearing the heavy register, even for one short moment, confirms that a normal chest voice can be produced by the larynx and that hypogonadism is out of the question.

The diagnosis is more difficult in cases of incomplete mutation. An important fact drawn from the voice history is that the mutation has proceeded imperceptibly. The sound of the voice is less characteristic than in the previous two conditions. There is no question of split registers, the pitch of the voice is too high, the tone is dull, it lacks the low resounding quality of the modal or heavy register and the origin of the poor voice quality goes back to the time of the mutation.

An abnormal use of the voice during puberty is found in the history of some cases of incomplete mutation. Patients who have continued to sing in a boys' choir long after the pubertal change of the larynx has set in may have impeded a normal transition of the vocal fold tissues to the postadolescent state. Also patients who have suffered from chronic non-specific respiratory diseases such as asthma often have a dysphonia similar to incomplete mutation. Tense breathing habits may have prevented these persons from establishing a pattern of relaxed and well controlled phonation.

The treatment of incomplete mutation is very different from that of prolonged mutation and mutation falsetto voice. In the latter is always possible to elicit a voice sound in normal register, by lower the larynx and pressure on the Adam's apple. The change to a normal voice should be abrupt, not gradual. The duration of treatment can usually be short. In incompletely mutated voices the treatment is aimed at achieving more supple cords: the structure of connective tissue and muscles in the folds must change. This requires intense work on the part of the patient over a period of months or years.

**Hypo- and hyperkinetic forms of habitual dysphonia and the resulting organic laryngeal pathology**

In many cases of poor vocal habits the delicate balance between subglottic pressure, breath flow and glottal resistance (firmness of closure) is neglected. When the vocal folds are not sufficiently closed and too much air is used, the voice sounds breathy. This is called hypokinetic dysphonia. When the glottis is firmly constricted, the resulting voice sound is harsh or croaking and is called hyperkinetic dysphonia. Sometimes it is hard to distinguish hypokinesis at the level of the glottis, hyperkinesis at the ventricular and pharynx level (constriction) and high thoracic breathing. In that case the issue is left undecided and termed 'dyskinesis'.
Prolonged use of improper vocal habits may cause the vocal folds to adapt to the strain by forming nodules, oedema and various forms of hyperplasia. The former are seen more in children and women, the latter in men.

**Vocal nodules**

Vocal cord nodules are a frequent disorder in children and adults. In children and adolescents they consist of spindle-shaped thickenings of the edges of the vocal cords, whereas in adults they constitute more localized thickenings, varying from small points to nodules, typically at the junction of the anterior and middle thirds of the vocal cords and always symmetrically on both cords.

Vocal nodules originate from a combination of overtaxing and incorrect use of the voice (habitual dysphonia). They can be prevented or cured by voice rest or by learning to use the voice properly. So strong is the influence of function on the form of the vocal cords, that the nodules can come and go in a matter of weeks, as has been observed many times in salesmen during a busy season or in women in a period of emotional stress. If the factors which have led to the nodules persist for a long time the nodules become permanent. A preliminary phase of submucous transudation is followed by an ingrowth of vessels, then by fibrous organization. At this stage resumption of normal functions leads to a slow return to normal.

The consistency of the nodules can be observed by laryngoscopy under stroboscopic light. A local oedematous swelling of recent onset vibrates in phase with the whole vocal fold whereas an older and more fibrous swelling can so impede the vibrations that only a part of the cord vibrates. The improvement in the vibratory pattern during restoration of the voice can be followed well by stroboscopy.

The treatment of choice is re-education of the voice by a suitable training programme that motivates the patient to practise in his home and work environment (Boone, 1981). Voice rest can be used in varying degrees. A complete voice rest, intended to be carried out literally, is too difficult for most patients to follow, because they would need to take sick leave and seclude themselves. The nodules will improve or disappear if this treatment is followed, but the question is what will happen as soon as the talking is resumed. The patient is then exposed again to the full burden of his daily life and work, still with his incorrected vocal habits. If they have not been changed in the interim, there is a high chance that the disorder will recur. There are two indications for voice rest: when the cause of the trouble has been a short-lived overtaxing of the voice; and as a preliminary to voice therapy. The patient who must learn new vocal habits is more likely to succeed if he is encouraged to give up his old habits. This is the case if he is freed from any vocal use apart from his exercises at the start of the retraining period. It has the best chance of success in a residential setting where all aspects of personal growth, resistance to stress and voice training are taken into account.

**Vocal fold oedema and laryngeal polyps**

A thin layer of loose connective tissue separates the epithelium of the folds from the underlying ligament and muscles. The potential space under the epithelium is called the subepithelial space of Reinke. Accumulation of fluid in this space is called vocal fold oedema;
if the accumulation is concentrated at one point and balloons the epithelium out in front of it, this is known as a vocal fold polyp.

Polyps can occur along the whole membranous parts of the vocal folds, but are most common near the anterior commissure. A polyp at that point can be easily overlooked because it is out of sight behind the epiglottis. It can be brought into view by having the patient lower his larynx during the mirror examination by yawning and falsetto phonation. In most cases the cause is unknown; some polyps may have originated from phonating with excessive subglottic air pressure and incompletely closed cords, so that the mucous membrane at the anterior commissure is sucked on and ballooned out. The accumulation of fluid in the subepithelial layer is later followed by the ingrowth of young connective tissue, so that the polyp eventually becomes firm in consistency.

Oedema of the vocal cords usually affects both sides symmetrically. It can be an after effect of acute laryngitis, particularly when the voice has not been spared during the inflammatory phase. In other patients it is the consequence of chronic overtaxing of the voice. Oedema has been seen to develop in professional speakers who were in the habit of speaking with an incompletely closed glottis. The oedema can be explained as an organic compensation, an attempt to close the chin. If this hypothesis is correct, it can be concluded that there is a risk in advising people to whisper in order to save their cords from damage during an inflammation. They can easily acquire a habit of speaking loudly with a breathy voice, while being convinced that in so doing they are sparing their voice. It is better to advise them to speak with a clear voice of low intensity and to avoid noisy places and large gatherings.

The pale appearance of swollen, oedematous vocal folds is unmistakable. It is more difficult to recognize a slight degree of vocal cord oedema. Listening to the voice may give a hint when the range is a semitone deeper than usual and high tones and falsetto tones become almost impossible. Stroboscopic examination shows a floppy wave edge and an enlarged vertical component of the vibratory pattern. A slight oedema will resolve in time; when there is a large colloidal mass beneath the epithelium resorption may take a long time and the patient may prefer to have the swollen mucosa removed, after which healthy epithelium will grow over the bare area. Voice therapy to control the breath flow and ensure sufficient glottal closure is indicated to prevent recurrence.

A vocal fold polyp never resolves and should be removed. Spontaneous cure may occur in a very early stage of a polyp, by rupture of the epithelium and escape of the contents which were not yet organized by connective tissue.

Hyperplasia of the epithelium

Improper use of the voice can play an important role in the inception of a series of epithelial changes, particularly when it coincides with smoking and alcohol intake. These three causes of chronic irritation combine to elicit adaptation reactions that are rather damaging to the voice: inflammation, acanthosis, hyperkeratosis. These conditions are discussed at length in a separate chapter and only the voice aspect will be mentioned here.
When examining the voice field and listening to the voice, it is observed that the patient cannot phonate at a low level of intensity. Because of the thickening of the epithelium, a higher than normal airflow is needed to start vocal fold vibration. The threshold of quiet phonation may lie as high as 60 dB in the phonetogram. The intensity range and the tonal range are limited. The hoarseness improves but does not disappear when posture and breath control are corrected.

Laryngostroboscopic examination is useful to determine the degree and the extent of the thickening and above all to check for malignancy. In the latter case there is absence of vibration of the infiltrated cord. In this way, follow-up with stroboscopic laryngoscopy can prevent unnecessary biopsies, a fact which is naturally important for preserving the voice function.

In principle, all secondary organic affections of the vocal cords, even those with epithelial hyperplasia are reversible if all causative factors are removed. Examples of complete remittance of severe forms of hyperplastic laryngitis have been observed when patients were admitted to the author's clinic, when they stopped smoking and drinking and learned new voice habits. Such a regimen is rarely practised and most patients prefer surgery combined with voice correction.

**Voice disorders of primarily organic origin**

In the voice problems discussed hitherto, the prime source of the trouble was always an incorrect use of the voice. In the diagnoses discussed here misuse of the voice has not necessarily been a causal factor. A summary of these diagnoses is found in Table 7.1 under the title Primary organic voice disorders.

**Vocal cord paralysis**

The causes and pathology of vocal cord paralysis are dealt with in Chapter 10.

An experienced examiner can suspect a vocal cord paralysis from the sound of the voice. Even if there is no clearly audible air waste, the voice sounds weak and thin, the lower register is lost and chest resonance is absent. This is explained by the difference in levels between the two cords: when the arytenoid of the normal cord adducts it also tilts forward, bringing the cord in a more caudal position than its paralysed counterpart. Thus the vibrating folds do not touch over their full medial surfaces.

During laryngostroboscopic examination a hypotonia of the paralysed cord can be seen: the amplitude of vibration of the affected cord is larger during phonation than that of the healthy side. When the glottis is not fully closed, the paralysed cord flutters like a flag in the wind.

Breathing can be disturbed in a bilateral paralysis with the cords in the paramedian position. The increased airway resistance is most noticeable on inspiration. Particularly rapid inspiration results in inspiratory stridor. It is for this, and other reasons a distressing syndrome (Holinger, 1981). In the opposite situation, with the cords fixed in an intermediate position, the glottis cannot be closed and offers too little resistance to the respiratory air, also during
phonation. If the patient speaks a good deal, the excessive displacement of respiratory air can result in hyperventilation. A decreased tension of carbon dioxide in the blood and tissues leads to peculiar complaints, which the patient seldom connects with his voice problem. These complaints include tingling in the fingers and feet (paraesthesia), feeling light in the head or dizzy, headache, irritability and emotional liability. It is wise to enquire about symptoms of the hyperventilation syndrome before beginning voice exercises.

**Treatment**

In a unilateral paralysis in the intermediate position, the aim of treatment is better glottic closure which can be achieved with exercises that make use of the remaining innervation and that stimulate compensation by adjoining muscles. The exercises consist of short well-controlled expiratory thrusts that bring the vocal folds into vibration. The Bernoulli (suction) effect narrows the glottis. External pressure by two fingers to the side of the larynx can improve the sound. Progress is measured by the duration of phonation. When proper care is taken development of a false vocal cord voice can be prevented.

**Surgical methods for improving the voice when exercises have not had the desired effect** are discussed in Chapter 10.

A bilateral paralysis in the paramedian position can develop into a situation in which the vocal cords lie closer together, in the median position. The voice improves, but the patient now has shortness of breath on inspiration and audible stridor. It is probable that this is caused by gradual reinnervation of the cricothyroid muscles allowing their adduction effect to come into action. When stridor and shortness of breath become serious there comes a point at which relief must be provided, either by a tracheostomy or by an operation to widen the glottis - lateral fixation of an arytenoid. In borderline cases, exercises for the improvement of breath control can forestall the necessity of an operation. When the glottic resistance is abnormally high, an improvement of the posture can provide just that little extra widening of the glottis which makes satisfactory breathing possible.

After an operation to widen the glottis one should not expect too much of the vocal function, because of the air escape during speaking. Voice exercises now serve to provide clear articulation and to reduce air waste to a minimum to prevent the symptoms of hyperventilation.

**Voice disturbances caused by endocrine dysfunctions**

A child's voice, the voice of an adult woman and that of a man sound different mainly because the sizes of the vocal folds and of the resonant tubes are small, medium and large respectively. The differences between the sexes (sexual dimorphism) are induced by genetic influence in the early embryonic development and are later elaborated by hormonal action during the period of rapid growth of puberty and adolescence. At a more mature age the effect of the sex hormones is more limited. Oestrogens administered to a grown man change the texture of the skin and hair and increase subcutaneous fat deposits on the breast and hips but do not change the timber and pitch to a perceptible degree. Androgens administered to a grown woman have a more marked effect. They cause extra nitrogen uptake and protein synthesis of the organs that harbour the male secondary sex characteristics: the size of the
vocal folds increases changing the voice in timbre and range, hair starts to grow in unusual places and there may be an enlargement of the clitoris. The effects of oestrogens on men and of androgens on women are different in another respect. In the former, feminization effects rapidly disappear after the intake of a hormone-like substances is discontinued. In the latter, the virilization effect on the voice persists.

Intersexuality

Aberrant sexual development may be caused by chromosomal abnormalities. XO and XXY are the most frequent abnormal chromosome sets. In the presence of only one X chromosome the individual develops into a girl with recognizable physical characteristics and decreased fertility (Turner' syndrome). The XXY constitution leads to individuals of male appearance who are infertile (Klinefelter's syndrome). During puberty they acquire fat deposits on the breasts and hips, the mutation of the voice is absent or incomplete, and there is little growth of facial hair. In this respect they resemble the eunuchoid syndrome. Testosterone stimulates development in a more virile direction. It has been suggested that the XYY constitution (an extra Y chromosome) contrasts with Klinefelter's syndrome by creating male individuals who are mostly mentally handicapped, over-aggressive and infertile.

Chromosomal abnormalities are comparatively rare and they are not the only cause of aberrant sexual development. The embryo's endocrine glands start to function during intrauterine life. The hormones thus produced play a role in the further development of the reproductive organs. The delicate balance of growth and differentiation can be rudely disturbed by a the relatively large amounts of estrogens produced by the placenta. It is assumed that a male embryo in a very early stage may undergo an influence from placental oestrogens which prevent full masculinization from taking place. The tissues do not respond to androgenic stimulation; this leads to pseudohermaphroditism (the non-virilizing testes syndrome). The baby is born with tests hidden in the labia or in the pelvis, the genitalia resembling those of the female type. The child is often reared as a girl until adolescence, when testosterone production by the hidden tests becomes strong enough to induce male sex characteristics. The voice changes, facial hair starts to grow and interest in girls appears. At that point it has to be admitted that at birth he had been registered with the wrong sex. In these cases a request to change the birth certificate is usually granted.

Eunuchoidism

In 1863 the Italian composer Rossini, not long before his death, wrote a 'Petite Messe Solennelle'. More than a century later it is impossible to comply with his advice for the performance: 'Twelve singers of three sexes will suffice: men, women and castratos'. The third sex is no longer trained in our schools of music. In order to enter a career as a castrato singer, boys under the age of puberty underwent an operation which deprived them of their testes. Thus, when at puberty the hypophyseal gonadotrophic and growth hormones were disinhibited and released into the circulation the gonadotrophic hormones did not find target organs that could start the production of testosterone. The growth hormone, however, induced a growth spurt. As a consequence no secondary male sex characteristic developed, but the limbs increased in length by growth uninhibited by the action of testosterone. Hence the tall stature of castratos or eunuchs; others of the third sex amassed large amounts of body fat and grew to extremely heavy proportions. The sexless, unearthly and heavenly quality of their voices
appealed to audiences, as at present many are enchanted by the extraordinary musical
possibilities of male alto voices.

The few castratos that still occur are usually caused by accidents. Other causes of
testicular hypogonadism are infectious diseases that lead to atrophy of the testes. When this
is recognized in time the hormonal defect can be substituted for by the administration of
testosterone.

In addition to the testicular form of hypogonadism, there is the (rare) condition of
hypophyseal hypogonadism. Klinefelter's syndrome has already been mentioned as a genetic
aberration with a deficient output of gonadotrophins, and subsequent hypogonadism and
eunuchoidism.

Sexual orientation and gender identity

In some conditions of abnormal sexual behaviour there is no evidence of genetic or
hormonal abnormality. It is very likely at the least that environmental factors have conditioned
the abnormality, possibly in interaction with internal predisposing factors.

Homosexuality does not give rise to any problem about sex characteristics of the
voice, because homosexuals, men and women alike, accept their gender and they feel no need
to change their appearance. The popular conception that male homosexuals would like to have
high-pitched voices was disproved by Lerman and Damsté (1969) who compared the mean
fundamental frequency of the speaking voice of 13 homosexuals and 13 heterosexuals.

In trans-sexuals there is a discrepancy between the somatic gender and the gender as
subjectively experienced. Some trans-sexuals feel a strong urge to live as a person of the
opposite sex, others have the firm conviction that they belong to the sex opposite to that
indicated by their bodies. Trans-sexuals may wish to change their physical sex characteristics
by surgical and hormonal treatment. In women, the transformation proceeds by surgical
removal of the breasts and the uterus and adnexa. Supplementary treatment by testosterone
causes facial hair to grow and the voice to change. In men, the surgical treatment consists of
removal of the penis and the testes and the construction of an artificial vagina. Treatment by
oestrogens develops breasts but will have little influence on the voice. Two courses of action
are available to change the male timbre of the voice: surgery, with the hazard of a limited
voice range and a poor quality of the voice, and training to attain habitual use of a light mid-
register instead of a low chest voice. This can lead to a satisfactory result if the client has the
required auditory discrimination ability and the motivation to practise intensively.

Virilization of the voice in women

Masculinization can occur in women of all ages. In girls before or at puberty it is
called perverse mutation. It is extremely rare and the cause is endogenous - a tumour of the
ovaries or the adrenal glands that produces testosterone.

A critical period for a woman's voice begins at the menopause, when periodic
ovulation and menstruation end. The hormonal balance shifts and with it come alterations in
the body chemistry inducing changes in elastic and collagenous fibres. These physiological
ageing processes can be compensated by good use of the voice. If the woman is a singer, she can take precautions that the chest register does not take control of her voice. If she practises her middle register daily in a mezza-voice, she can continue to use her feminine voice into old age.

At the present time women have to be even more on their guard if they want to follow a natural development of the voice after the menopause. Some women are prescribed testosterone at this time of their lives, because it relieves certain disagreeable symptoms related to the climacteric. This treatment always affects the voice sooner or later. The individual sensitivity to androgens varies and so does the sensitivity for noticing the first change in the voice. Some notice a difference after one or two injections or a few weeks of oral administration; others do not complain even though they suffer gross alterations of the voice.

The anabolic steroids are related to the androgenic hormones. They are prescribed in chronic debilitating diseases and in the presence of metastases of ovarian cancer. Virilization by drugs such as these is marked by voice change before other symptoms of virilization appear. These other symptoms, especially hirsutism (hair on the face and legs) are usually prominent and early signs when the virilization is the result of an endogenous cause (the Stein-Leventhal ovarian dysfunction, or ovarian tumours).

It is important that the initial symptoms of voice virilization are recognized, because only then can the drug be stopped in time to prevent more severe damage to the voice. The early signs are so inconspicuous that the patient is often more impressed by a slight change of her voice than the doctor, to whom the voice still seems within the normal range of pitch and quality. Only by careful questioning and listening to the patient's subjective report, can the doctor discriminate between this incipient organic disorder and other more passing organic or functional disorders. One listens to unsteadiness of the timbre: repeated changes between a full resonant and a thin falsetto-like voice sound within one spoken sentence. The difference between the two qualities of the timbre are very slight in the beginning. When virilization progresses a split in normal and falsetto register will become evident. In case of doubt the reaction of the patient to the almost imperceptible change of her voice is the decisive cue: the voice sounds strange to her, it is not under control as it used to be, especially in the high tones. People who sing, professionally or as amateurs, will of course perceive this at an earlier stage than others.

In an advanced stage of voice virilization the lower part of the voice range has a distinct heavy quality like the chest register that is normal for men. Some victims of virilization feel extremely self-conscious about this chest voice and try to avoid the low tones, even during the examination of the voice range.

Most authors agree that the structural change in the vocal folds caused by the virilizing agent cannot be reversed, even over a long period. The organic structure is irreversibly changed and demands a functional compensation. Blending the registers is an important goal of practice. The prognosis depends on the stage to which masculinization has progressed, the age of the patient, and her ability to compensate the damaged function, based on a good musical ear and phonatory control.
Other hormonally-induced voice disorders

Laryngopathia gravidarum is a disorder of pregnancy, a time during which oestrogens are produced in great quantities. These may cause mild oedema of the vocal folds, as in premenstrual hoarseness. The voice is somewhat lower and gruffer than normal. In predisposed women the disorder can assume a more serious form, with redness and oedematous swelling of the epithelium of the vocal folds, the ventricular bands and the aryepiglottic folds, sometimes with haemorrhage and loss of the epithelium. In another form, crust formation is the most prominent symptom.

The voice disorder can proceed to complete aphonia with stridor and shortness of breath. The inflammatory appearance has a hormonal cause: once the pregnancy is over the disorder usually resolves completely.

*Hypothyroidism* (decreased function of the thyroid gland) in early childhood leads to dwarfism and mental retardation - cretinism. In later life it causes myxoedema, that is a thickening of the subcutaneous tissue; the patient is sensitive to cold, sluggish and shows little mental initiative; the voice is monotonous, low and dull; speech is slow with laborious articulation. All this is often incorrectly interpreted as normal symptoms of old age. If correctly interpreted, substitution therapy brings a marked improvement. Anginal chest pains, resembling cardiac complaints, may accompany the symptoms and deflect attention away from the true cause.

*Hyperthyroidism* produces the opposite symptoms: the voice is clear, high and animated, but tends to instability and is quick to tire. Poor coordination between respiratory and laryngeal control may produce hoarseness. Other symptoms of thyrotoxicosis are irritability, anxiety and tenseness.

Thyroid enlargement without toxic symptoms can also cause voice complaints as a result of displacement of the pretracheal muscles, and in serious cases by compression of the trachea. The dysphonia after thyroidectomy, described in the section on vocal cord paralysis, is notorious.

*Congenital abnormalities of the larynx*

When the voice has been abnormal since early childhood a congenital cause should be suspected, particularly when a functional examination shows that the intensity and the range of the voice are limited. An indirect or direct laryngoscopy may be necessary to confirm a suspected congenital may be necessary to confirm a suspected congenital disorder, but this can be too radial, especially in a very young child, if nothing more is gained than confirmed diagnosis of a condition that cannot be corrected. The author recommends this investigation only if there is a reasonable expectation that laryngoscopy will lead to corrective surgery, as in the case of laryngeal web.

Webbing of the anterior commissure considerably reduces the freedom of the vocal folds to vibrate. The voice sounds unusually high and breathy and cannot produce a powerful tone. The treatment is surgery, followed by re-education of the voice.
Another congenital condition is asymmetry of the vocal folds as a result of:

1. unequal length of the cords;
2. unequal mobility of the cords, which can be explained as a congenital paresis;
3. a difference in the level of the cords which can result from either of the above.

Finally two rare conditions which may lead to a mild form of voice handicap should be mentioned. One is the 'sulcus glottidis', a groove along the length of one or both vocal folds, perhaps a hypoplasia of the connective tissue (Itoh et al, 1983). The other is over-elasticity of the vocal cord ligament that is sometimes observed in boys and girls with hyperextensible joints in Ehler-Danlos syndrome. It results in a peculiar low and monotonous voice. These disorders do not usually require surgical treatment. Injection of Teflon suspension may be considered, but should only be carried out by a specialist in phonosurgery.

**Other primary organic voice disorders**

**Senile atrophy**

Women of advanced age may speak in a voice with a lower than normal pitch because of vocal fold oedema or hypothyroidism (Honjo and Isshiki, 1980). In some old men the voice may assume a light timbre and a high pitch. At the same time they lose the ability to phonate in the chest register. The cause of this is probably shrinking of the muscle mass of the cords or stiffening of the vocal membrane and the vocal fold ligaments, so that they lose the suppleness required for the production of the chest register.

It is certainly not a general symptom of old age.

**Cysts of the vocal folds**

Two cysts of importance in phoniatrics are the mucous retention cyst and the epithelial inclusion cyst. Both can result from laryngitis and they can interfere with the voice function to a greater or lesser degree, depending on their site. As this is usually halfway along the membranaceous part of the folds the symptoms can be considerable. They may be visually inconspicuous and may appear as a unilateral nodule or hide under 'monocorditis' (Monday et al, 1983). Small cysts near the edge of a vocal fold can cause a diplophonia; that is a double or interrupted tone, caused by the inequality of the vibrating masses of the two folds. Cysts are removed assuming that the underlying connective tissue is not damaged. After the operation a period of voice therapy is usually necessary to correct habits formed while the cyst was still present.

**Inflammation**

Specific inflammations of the larynx, such as tuberculosis, syphilis and granulomata are dealt with in Chapter 6.
Papillomatosis of the larynx

When dysphonia has been present for some time and shows a gradual progression, laryngoscopy may reveal a warty epithelial mass on one of the cords. The diagnosis of a papilloma is confirmed by histological examination of the specimen, which shows a characteristic arrangement of the cells in this benign epithelioma. In adults, surgical removal of the growth is unlikely to be followed by a recurrence. However, in children these tumours are apt to recur, and multiple papillomata may occur on both vocal cords and the false cords, sometimes extending to the epiglottis and the trachea.

The prognosis improves with age: the chance of extension and recurrence becomes much less with the attainment of adulthood. The quality of the voice should then be reasonable provided that multiple operations have not caused permanent scarring and stenosis. Treatment must therefore ensure that damage to the growing larynx is avoided and that subepithelial layers are not damaged. Training in non-traumatic use of the voice makes sense because continuous trauma caused by incorrect voice use might stimulate the growth of papillomatous tissues.

Trauma to the larynx

Direct trauma to the larynx can be caused by traffic accidents for example the neck can be struck by a projecting part of a car or motor bicycle. A cartilaginous fracture, a ligamentous tear or a rupture of the trachea may occur. After the life-threatening condition has healed the effects on the function of the vocal folds must be considered. Mucosal adhesions can impede the movement and vibration of the vocal folds. In addition, the slightest interference with the cricothyroid or cricoarytenoid joints can influence the regulation of tension of the cords unfavourably, resulting in huskiness of the voice.

The examination presents certain difficulties. Since there are numerous other causes of dysphonia, it may not be easy in a particular case to decide if the symptoms are connected with an accident, especially if this occurred a long time ago. This problem is particularly difficult if there is question of financial compensation.

In testing the vocal function it is important to determine the margin between the available functions on the one hand and to what extent they are being used on the other. The margin can be reduced by retraining of the vocal function.

The prognosis for the voice depends on the findings at indirect laryngoscopy with respect to the position and mobility of the arytenoids, the aperture and closure of the glottis and difference in the levels of both vocal cords. Adhesions can be removed or a cord can be moved to a more favourable position by injection of a suspension of Teflon to improve the voice. On the other hand, unexpected results have been obtained by continued voice exercises. Experience has shown that once one has succeeded in making a vocal fold vibrate in the airstream, regular voice use will bring about a further improvement. The form of the vocal fold is undoubtedly modified by the use of the voice. Some feel that this can be ascribed to the Bernoulli effect, the medially directed sucking force of the airstream by its modelling action, progressively broadening a narrow fold. To produce a tolerable voice with a somewhat rudimentary instrument is a greater art than when the normal cords are present. Re-education
of the voice requires considerable skill on the part of the therapist and tenacity and optimism on the part of the patient.

Stenosis of the larynx in children before the onset of speech gives rise to compensatory voice mechanisms. In the absence of laryngeal voice, these children develop a form of buccal voice, a 'frog's speech'. With the help of movements of the tongue and the bottom of the mouth, air is pressed along the pharyngeal arch which is thus made to vibrate. The sound so produced is only capable of abnormal articulation, but it can, nevertheless, be understood by persons closely associated with the child.

In a number of cases of laryngeal stenosis a satisfactory lumen can be obtained by plastic reconstruction. Where this has not been possible the remaining lumen has been fitted with an acrylic tube which allowed sufficient air to be forced through the larynx to produce voice. In that case, the patient remains dependent on a tracheostomy for respiration.

Cancer of the vocal cords

Hoarseness is so common that despite this early symptom, vocal cord cancer is often ignored for a long time. Also, this disease does not usually strike like a bolt from the blue, but affects mainly smokers for whom a morning cough and break in the voice from collected mucus is nothing unusual. The hoarseness must then have reached a certain degree of seriousness and persistence before it becomes a reason for the patient to see his doctor. It is therefore a good rule that if a patient has been hoarse for 6 weeks he should be examined by a throat specialist. Typically this form of hoarseness is constant (not intermittent as in functional dysphonia), and does not improve but rather progressively worsens. Stroboscopic laryngoscopy may aid in the differential diagnosis from hyperplastic laryngitis: malignant infiltration must be suspected when the affected vocal cord is seen not to vibrate in stroboscopic light. Stroboscopic examination can also be used for follow-up after radiotherapy: if the hoarseness has not resolved and the vibrations of the vocal fold have not returned to normal, it is justifiable to suspect that the tumour has not completely resolved. Radical surgery will have to follow without too much delay.

Rehabilitation of the voice after laryngectomy

Since the prognosis for cancer of the larynx is better than for some other forms of carcinoma, a successful effort at rehabilitation is especially rewarding. Through all the remaining years the patient enjoys an improved quality of life if he has learnt to use a good substitute voice.

The appropriate time to begin speech training after surgery depends on the local condition of the wound and on the general condition of the patient. The wound should be healed without fistula and the mirror should show no trace of fibrin in the pharynx. For his general condition the patient is encouraged to take walks and other forms of exercise. The condition of his (false) teeth is checked. An audiogram is made as a preliminary to voice and speech training.

Informing the patient and his/her spouse is an essential part of the rehabilitation programme. Usually the nature and the consequences of the operation have been discussed
before the operation. The spouse should always be present in such an informative session: the partners can discuss matters between them and what one has missed will have been heard and understood by the other. In the stress of the preoperative period much of what has been said is not remembered. It is a good idea to repeat the information in the more quiet period after the patient has recovered from the surgery. Among the points to be discussed are:

(1) the altered anatomy;

(2) moisturizing and cleaning the stoma;

(3) types of substitute voice;

(4) useful aids and appliances;

(5) the address of the Association of Laryngectomized Patients;

(6) other questions brought up by the patient and his spouse.

Depending on the organization of the clinic, most of the informative sessions will be held by a doctor, a nurse or a speech therapist. The person responsible should be aware that these sessions do more than furnish matter-of-fact information. Counselling after radical surgery includes guiding a person through phases of recovery from a heavy loss. The counsellor will have to cope with periods of depression, anxiety or protest. With his or her help and the cooperation of an understanding partner or relative, the patient will ultimately accept his handicapped condition. Only then will he be ready to concentrate on assignments and exercises for his rehabilitation.

The artificial larynx

After laryngectomy the patient is offered the choice between using an external voice prosthesis or learning oesophageal speech. The third and perhaps best choice is practising oesophageal speech while using an artificial larynx for speech situations in which oesophageal speech cannot yet meet the demands. The artificial voice generators are essentially of two types: the pneumatic, activated by the respiratory air from the tracheostoma, and the electric, driven by batteries. The first has several advantages: it can be used the day after the operation, provided it can be connected to the tracheal cannula; by carefully choosing the material for the vibrating membrane a suitable pitch and quality of the voice can be selected; because the pitch varies with the breath pressure, the fundamental frequency approaches normal speech intonation; it has no battery that can run out; it is cheap. Some patients dislike the polyethylene or metal tube that transmits the sound from the vibrator at the stoma to the mouth, and see this as a disadvantage. Typical examples of pneumatic voice prostheses are the Tokyo artificial larynx and the Memacon DSP 8.

Of the many electric external vibrators that are available most have an adjustable pitch and intensity level. Servox has the option of a manually operated tonal accent device, the use of which requires linguistic as well as other skills. All voice prostheses have the disadvantage that one hand is occupied when speaking. Every year new developments are reported so that
hope for further improvements is entirely justified. Details about training in the use of artificial larynges are discussed by Keith and Darley (1986).

**Oesophageal speech**

Surgeons who performed laryngectomies early in the 20th century reported that, to their surprise, several of their patients sooner or later, developed intelligible speech, but only those patients with no external pharyngeal fistula. In the early days of the operation a pharyngostoma was a frequent complication which interfered with food intake and with development of substitute speech. The mysteries of speech without a larynx have been solved in subsequent years. At the present time every laryngectomized patient should have access to voice rehabilitation immediately after the surgical wound has healed and the feeding tube has been removed.

When a patient is left to his own devices after laryngectomy and he attempts to speak, the result is initially poor. His lips move, but no sounds come out of his mouth - no vowels because there is no voice, and no consonants because there is no airstream with which they can be articulated. After some practice the patient can learn to move the floor of the mouth and the root of the tongue in such a way that some air is displaced, enough to produce short sibilant and plosive sounds. This can lead to pseudo-whispered speech which is not a real whisper because it lacks the sighing sound of the glottis. It is produced with effort and lacks some indispensable voice sounds, so that it is difficult to understand. As has been mentioned under stenosis of the larynx there are people who learned to vibrate the pharyngeal arch with such a mechanism, producing a buccal speech or 'frog's' speech. It is a type of speech which can only be understood by the initiated and there is no reason to encourage its use by laryngectomies. On the contrary, as a sequel to pseudo-whispered speech the patient may develop so-called pharyngeal voice, which is equally unsatisfactory and is a blind alley on the road to oesophageal voice. It is produced by contractions of the pharynx, which is just the thing to be avoided when learning to produce oesophageal speech. The correct manner in which the patient can generate a properly understandable substitute voice, is by taking air into the oesophagus. When, immediately after the intake, the air is returned, it makes the mouth of the oesophagus vibrate resulting in a vowel-like sound, resounding in a wide pharyngeal and oral cavity.

**The initial stage**

When attempting to make his first oesophageal sounds, any manner or manoeuvre by which the patient succeeds is correct for that particular patient. There is no single method that will be suitable for all. There are several possibilities:

1. drawing air into the oesophagus by inhalation; the entrance of the oesophagus should be opened during an inspiration;
2. pumping air into the oesophagus by injection; the tongue and the floor of the mouth compress the air, while the entrance to the oesophagus is relaxed;
3. carbonated water is used to help the patient form his first recognizable words with 'second voice'.

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A patient who is well instructed in his rehabilitation will soon find out which method of air intake suits him best. A few experienced laryngectomized speakers take air in by inhalation. Most experienced patients can speak two to five syllables on one intake. Eventually, replenishing the air in the oesophagus is achieved so unobtrusively that it is hardly noticed. The basic sound is usually learned within 1 or 2 days. It takes 2-10 weeks before the patient can use his newly acquired voice outside his own home and the quality further improves over the next year.

**Difficulties encountered in acquiring oesophageal voice**

The most frequent problem for beginners is that the oesophageal mouth does not relax at the moment that the air must pass through it on the way in or out. When the air does not get farther than the pharynx, the sound produced is tense, high pitched and of short duration that is unsuitable as a substitute voice. Sometimes a patient succeeds in injecting air into the oesophagus but is unable to return it at will. When more than a fraction of a second elapses between injection of air and phonation, the air is passed on to the stomach and is lost for phonation. The problem is sometimes solved by active relaxation training of the muscles of the neck and jaw: an indirect approach to relax the oesophageal sphincter. In stubborn cases dilatation by an oesophageal bougie and insufflation of air by a catheter can help to overcome the sphincteric contraction reflex.

A diverticulum of the pharyngeal wall can have an adverse influence on the sound of the voice which may be moist and bubbling. Such a diverticulum is best prevented by stitching the pharyngeal wall with the greatest care and ensuring that the patient does not swallow in the first days after operation.

A distracting symptom in some oesophageal speakers is an audible sound made by air passing through the stoma or the tracheostomy tube. It can sometimes be improved by teaching the patient a more controlled method of breathing during speech.

Some patients complain that their voice is too weak to be of any use in other than the quietest environments. This can be caused by flaccidity of the pharyngeal wall at the level of the vibrating structures. If light finger pressure on the skin above the tracheostoma improves the quality of the voice a special neckband that applies permanent pressure can be fitted.

**Measures for restoring other functions**

The sense of smell, that is often absent in laryngectomees, can be restored. The patient learns to ventilate the nose by making the same pumping movements as he uses to inject air in the oesophagus, this time with the soft palate lowered. It is attempted as follows: the root of the tongue is moved up and down and one nostril is closed off by a finger. A hissing noise through the other nasal opening betrays that air is moving. Mastery of this skill ensures that the patient can detect noxious gases in his home, can enjoy agreeable smells in the countryside and can enjoy the taste of his food better.

Swimming is not necessarily impossible for laryngectomees who engaged in this sport before the operation. A cannula with an inflatable cuff is inserted in the trachea. An airhose connected to the cannula at one end leads to a snorkel at the other fixed to the head by an
elastic band. After the cuff has been inflated, a thorough check is made so that no air escapes past the cannula when the swimmer breathes out with the neck under water. The snorkeler will have to become used to the larger dead space, which requires him to breathe more deeply, by practice sessions on dry land before actually entering the water. Being able to swim again means much for many laryngectomees: it reduces the sense of being handicapped and enables those for whom many other sports have become impossible to stay in good health.

A surgical prosthetic method to restore the voice after laryngectomy

A disadvantage of the oesophageal voice is that the small supply of air that is available for phonation necessitates repeated interruptions of the speech flow for the intake of air. This drawback has been met by a procedure described by Singer, Blom and Hamaker (1981). The wall between the trachea and the upper oesophagus is punctured during endoscopy. A tube of about 4 mm diameter ending in a valve is inserted in the opening. It has dual functions: it keeps the fistula open and it allows air from the trachea to pass into the oesophagus when the patient closes off his stoma and breathes out. The voice that is produced is generated at the pharyngo-oesophageal junction, as is oesophageal voice. The difference is that more air is available for speech. The advantages are that speech is immediately available after operation, and that sustained speech is produced with a fluent quality. Disadvantages are that one hand is occupied during speech and the patient remains dependents on the hospital for replacements of the tube every 3 or 4 months.