Restoration of voice after laryngectomy

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The importance of speech is not fully appreciated until the voice is lost. Speech is more than verbal communication; in addition, vocal intonation displays our emotional state. Cancer of the larynx is the most common head and neck malignancy in the western world[1] and for a long time the only available treatment was major laryngeal surgery, (Billroth did the first total laryngectomy in 1873). Fortunately, since the advent of cobalt-60 in the 1950s and the improvement in endoscopic techniques, many patients with early disease can now be cured with radiotherapy alone or with minor surgical interventions that preserve the voice[2–5]. For some, however—those who do not respond and have residual disease or recurrence, and those who present with advanced disease—a major laryngeal resection provides the only hope of cure[6,7]. In a minority of cases partial laryngeal surgery, avoiding a permanent tracheostome, is feasible. However, the resulting voice is often poor and swallowing problems, especially aspiration, can be debilitating. In the UK, most patients who proceed to surgery still undergo a total laryngectomy. This involves the permanent separation of the respiratory tract from the upper digestive tract and the removal of the most important anatomical unit involved in voice production. It is a mutilating operation with lifelong functional and psychological consequences.

Laryngectomized patients have a relatively favourable prognosis, with a 5-year survival rate of 65–75%[8]. Although this survival rate has changed little over the past 25 years, developments in post-laryngectomy speech rehabilitation have led to substantial improvements in quality of life. Here we offer a review of voice rehabilitation techniques.

PHYSIOLOGY AND VOICE PRODUCTION

To appreciate the techniques of voice production following total laryngectomy it is necessary to understand the basic mechanisms involved in normal voice production. Voice is produced by the respiratory tract, with three levels serving different functions (Figure 1).

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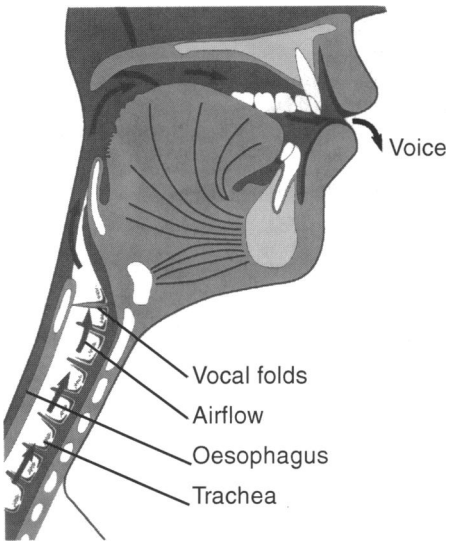

Figure 1 **Normal anatomy**

The lungs act as a bellows. Voice results from movement of an air column through the adducted vocal cords and this is produced, in most cases, on expiration by collapse of the lungs through elastic recoil and muscular relaxation. The voice generator is the larynx. This organ causes the air column to vibrate, producing an audible sound: active adduction of the vocal cords generates a travelling mucosal wave on the surface of each membranous vocal cord (Bernoulli principle). The sound wave thus generated reaches the voice resonator comprising the muscular pharynx and oral cavity. The vibration and variation in muscle tone of this part of the respiratory tract enable certain sound frequencies to be transmitted and certain others to be suppressed.

Since removal of the larynx results in loss of the sound generator (Figure 2), voice can no longer be produced in a normal manner. However, two of the three components of the voice-producing mechanism remain, and replacement of the third by generation of sound in different ways forms the basis of post-laryngectomy voice rehabilitation.

OPTIONS

Ever since the first laryngectomy was performed, post-operative voice rehabilitation has been of major concern to head and neck surgeons. Gussenbauer, Billroth's assistant, used a reed-valve placed through a temporary pharyngo-stome so that expired air could be set into vibration by the

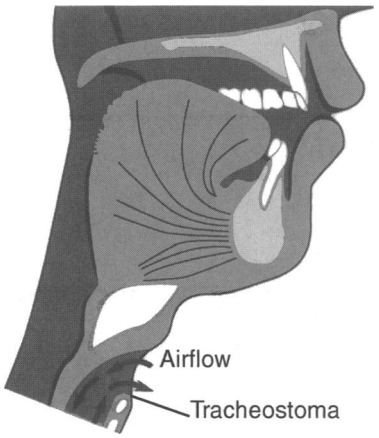

Figure 2 **Anatomy after laryngectomy**

valve and redirected through the pharynx and buccal cavity, allowing speech production[9]. The primary purpose of the pharyngostome was to prevent pulmonary complications secondary to wound breakdown, a common occurrence at that time. With the development of improved operative techniques avoiding the necessity of a temporary pharyngostome, this method of voice production was lost. Since then various alternative techniques have evolved. They may be broadly subdivided under three headings—oesophageal speech; surgical methods (external methods/external fistulae, or internal methods/internal fistulae); artificial larynx.

With the passage of time some methods were refined and others fell into general disuse, and by the early 1970s the main voice rehabilitation techniques were oesophageal speech and voice production with an artificial larynx. Since then, with improvements in technology and the increasing availability of suitable biocompatible materials, an indwelling one-way valved prosthesis has become the most popular method for speech rehabilitation. By connecting the trachea and the oesophagus this achieves reported fluency rates of 90%[10].

Whatever speech rehabilitation method is used, it is important that the patient ('laryngectomee') be motivated and encouraged by a multidisciplinary team including the surgeon, the speech therapist, and a successfully voicing laryngectomee.

OESOPHAGEAL SPEECH

Surgeons who performed laryngectomies in the early 20th century reported that, to their surprise, some patients went on to developed intelligible speech. This was noted to occur only in patients without a pharyngocutaneous fistula (a frequent complication in these early operations). The mystery of speech without a larynx was solved by Seeman[11], who in 1922 recognized that in some cases the cervical oesophagus could effectively act as a neoglottis and the distal oesophagus and stomach as an air reservoir. Since then this technique, known as oesophageal speech, has been widely adopted.

Oesophageal speech is produced when air is swallowed and regurgitated in a controlled manner so that the column of air passing upwards through the pharyngo-oesophageal segment produces sound by vibration of these tissues. Voice is then produced by mouthing words in the normal manner.

Some 14 to 76% of patients develop oesophageal speech[12]. Reasons for the wide variation are unclear. One factor that causes patients to discontinue this method is severe heartburn and bloating on swallowing air[13]. Another factor may be that oesophageal speech, when successful, provides most laryngectomized patients with a harsh voice of low pitch and low volume, adequate only for communication in small groups and quiet settings[14]. The character of the voice is particularly unpopular with female patients. Furthermore, motivation to practise and support from family and friends is necessary if this technique is to be successfully acquired[15].

Although oesophageal speech may not be easy to achieve, it has the advantages of not requiring a surgical procedure or a prosthesis, and is devoid of major complications.

SURGICAL METHODS

All these methods entail the creation of an internal or external fistula between the airway and the pharynx.

External methods/external fistulae

Almost all methods involving external fistulae have now been abandoned, largely because of the complexity of the surgical technique and the equipment. For example, the voiceback technique developed by Taub and Spiro[16] required both an external prosthesis connected to the trachea and an oesophagocutaneous fistula. Its principal drawback was that it was unsuitable for use in the irradiated neck or in the patient who had undergone a neck dissection. The scrupulous maintenance required also made the device impractical. Aspiration of saliva and food were the risks of another technique described by Conley[17].

Internal methods/internal fistulae

In much more widespread use are the techniques involving the formation of an internal fistula. These can be subdivided into two main categories:

- Surgical techniques in which the patient's own tissues are used to create a tracheo-oesophageal or tracheo-pharyngeal fistula.

- Tracheoesophageal fistula by direct puncture, either at or some time after primary laryngectomy; the patient wears an artificial valved prosthesis in the fistula[10,18,19].

In the first group various techniques have been described[20,21], with success rates with regard to voice production between 20% and 76%, but all carry high complication rates, mainly due to shunt breakdown and aspiration. Because of this and the complexity of some of the procedures, their use has not become widespread.

The second method employs bioinert synthetic one-way valves such as those designed by Blom and Singer[10]. Because they are simple and the complications associated with their use are not serious, such valves have become the most commonly employed technique for the production of voice after laryngectomy.

Tracheo-oesophageal puncture is a minor surgical procedure, in which a fistula is created through the tracheo-oesophageal party wall either primarily during laryngectomy or secondarily when the tracheostoma is fully healed. Once the fistula has been created, a prosthetic tube about 4 mm in diameter, containing a one-way valve, is inserted (Figure 3). By allowing inhaled air to pass only one way from the lungs to the oesophagus, when the patient exhales against a blocked off tracheostome, voice is produced without aspiration—generated, like oesophageal voice, at the pharyngo-oesophageal junction. The advantage of this technique is that more air is available for speech and that sustained speech is produced with a fluent quality. A further advantage is that, when the surgical procedure for the insertion of the voice prosthesis is performed at the time of the laryngectomy, the patient will be able to speak within a few days. This may help the patient's psychological state[22]. Disadvantages are that in most cases a thumb is required to occlude the stoma during speech, and the patient remains dependent on the hospital for replacement of the prosthesis every few months, since the valves fail with time and aspiration results. Failure is usually due to candida colonization. The life of the valve can be increased by the daily use of nystatin, but is still only 6–9 months[23].

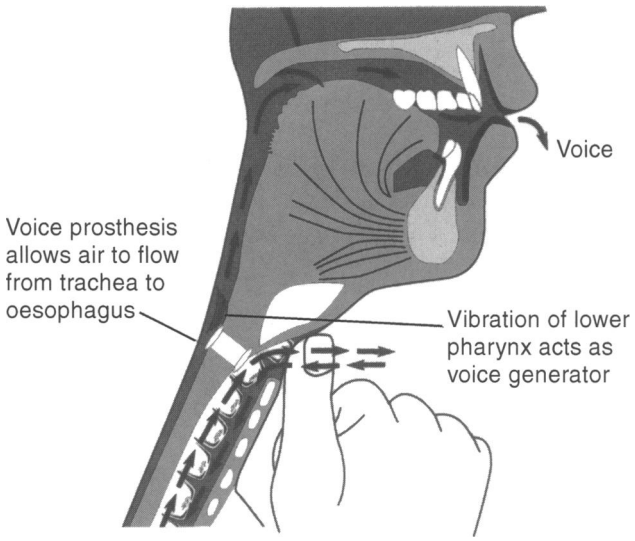

Figure 3 **Tracheo-oesophageal voice of prosthesis**

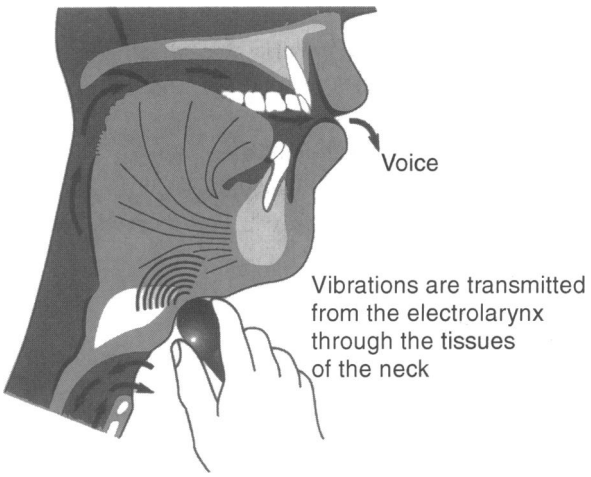

Figure 4 **The electrolarynx**

ARTIFICIAL LARYNGES

Artificial voice generators are often regarded as the last resort, suitable only for those patients who have been unsuccessful in gaining intelligible voice with the other methods. However, in selected cases these devices may be primarily indicated. Some patients, such as those who have undergone previous radiotherapy, have a poorly vascularized stoma; and in these cases the fistula may enlarge progressively and lead to aspiration. Others, frail and elderly or with neurological disorders such as Parkinson's disease, do not have the proprioceptive capabilities to care for their valve, which needs daily cleaning, or to occlude the stoma to speak. In both these groups such a device should be considered.

There are essentially two types of artificial larynx. The pneumatic larynx is activated by respiratory air from the tracheostome via a connection to a tracheal canula. These have the advantage of not requiring a battery and the fact that the pitch varies with breath pressure, which results in fundamental frequencies that approach normal speech intonation. Despite this they have not won widespread acceptance, probably because patients regard them as cumbersome and do not like the plastic or metal tube that transmits the sound from the vibrator at the stoma to the mouth. The electrolarynx is a hand-held, battery-driven device and uses a diaphragm, acted on by an electromechanical vibrator. When the diaphragm is held tightly against the neck (Figure 4), its vibrations are transmitted through the tissues of the neck and emerge from the vocal tract, where the user modulates them with the mouth to create speech[24]. This device is often used in the immediate

postoperative period, but the rate of long-term acceptance is rather low—probably because the speech produced is rather mechanical ('dalek' sounding) and the perceived voice quality is monotonous.

Finally we should mention that, despite all efforts, between 10 and 15% of laryngectomees fail to acquire any form of verbal communication[25]. For them the solution remains to be found.

CONCLUSION

It is of vital importance that patients who require laryngectomy are properly counselled preoperatively. The most devastating outcome of the procedure is the loss of voice. Most can regain voice by one means or another. The tracheo-oesophageal valve is today the method most frequently used, but alternatives should not be forgotten.

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