Postlaryngectomy voice rehabilitation with voice prostheses

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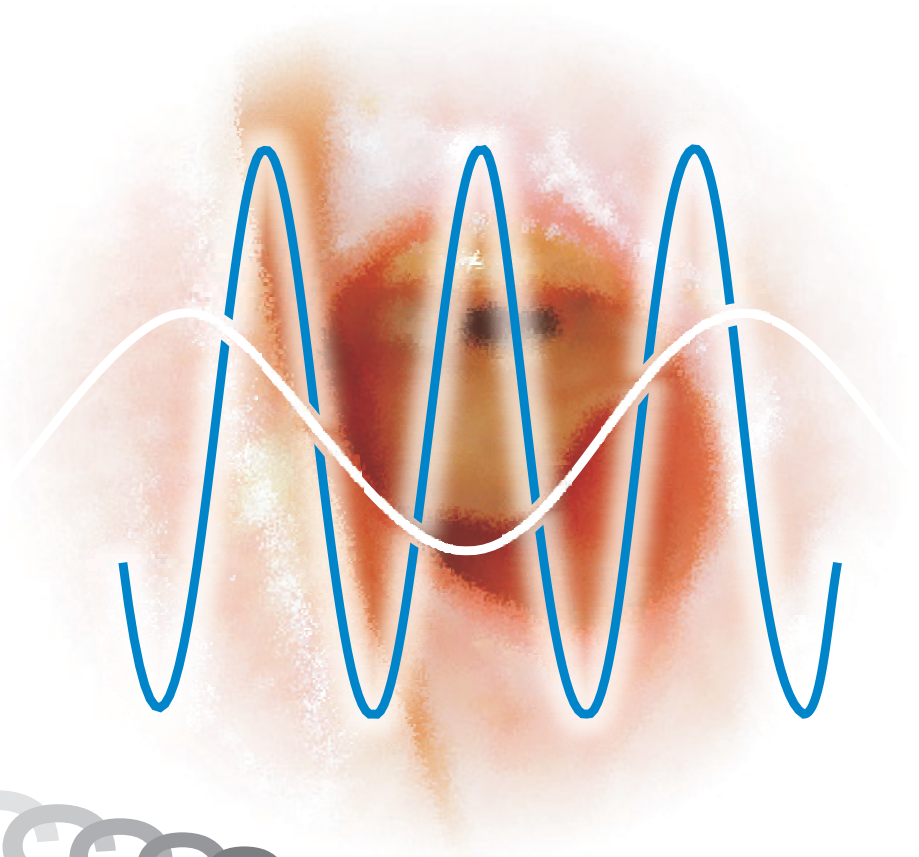

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Preface and acknowledgements

Over the last 30 years, the use of voice prostheses has become the gold standard for voice rehabilitation after total laryngectomy in the industrialised nations. Besides the high success rate of approximately 90% for adequate restoration of the ability to communicate verbally, the procedure is characterised by a short operating time, low intraoperative risk and straightforward technical complexity. Phonation is usually achieved as early as the first postoperative week if there is an interdisciplinary team of doctor, nurse, speech therapist and individual who can advise on aids.

The rate of complications with voice prostheses should be regarded as low: severe, mostly intraoperative or perioperative incidents occur only as isolated case reports. Minor problems generally relate to material fatigue or contamination of the prosthesis and can be managed by simple procedures. However, there are also problems with the use of voice prostheses and diagnosing and treating these problems requires a certain amount of experience and treatment algorithms.

As there are still uncertainties and lack of clarity in many places about the treatment of problems associated with voice prostheses, this book specifically deals with the subject of the management of complications after prosthetic voice rehabilitation. In order to do this, a team of authors was formed which already has experience over many decades in the use of voice prostheses and the treatment of laryngectomised patients and has, moreover, specifically dealt with this range of problems scientifically.

This book aims to give the current state of the management of problems with voice prostheses both from the ENT/surgical standpoint and from the speech therapy standpoint and to provide a guide to surgeons for the treatment their patients.

In order to do this, emphasis has been placed on a clear organisation of information and many illustrations, drawings and tables. In addition to the fundamentals of voice rehabilitation, the treatment of different types of leakage and phonation deficits is discussed as are the speech therapy principles and treatment strategies. There is also information on voice prosthesis replacement and the use of special prostheses.

Through this book, we hope that the reader enjoys this wealth of experience and that any uncertainties or reservations of interested colleagues can be eliminated.

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Ulm, January 2017 *Kai Johannes Lorenz*

Foreword

As was already the case more than 100 years ago, laryngectomy is an important treatment option in advanced laryngeal cancer. In the past, this procedure was often tantamount to voice loss and thus a greatly reduced ability to communicate. For affected patients, this fact was just as debilitating as having cancer.

Not least for this very reason, possibilities for voice rehabilitation were looked for right after this procedure became established. Following the first attempt at surgical voice rehabilitation after laryngectomy by Gussenbauer in 1873, numerous surgical techniques were established, some of which enabled good functional results to be obtained, but frequently at the expense of severe complications or considerable complexity. These surgical techniques were accordingly unable to become firmly established compared with voice rehabilitation through learning oesophageal speech, despite often having better functional results.

This situation has quickly changed with the development of modern voice prostheses. For the first time, a procedure was available that could be performed easily and immediately after laryngectomy and did not involve any significant intraoperative risks for the patient. Over the last 20 years, use of voice prostheses has become the standard procedure for voice rehabilitation after laryngectomy in Germany. Viewed retrospectively, the majority of patients have been able to achieve reproducibly good phonation results. Over time, however, long-term complications have also become evident. These are dominated by enlargement of the tracheo-oesophageal puncture. The spectrum ranges from minor periprosthetic leakage to extensive defects in the paries membranaceus, which may be associated with an unacceptable reduction in quality of life and require immediate appropriate therapy.

For this reason, every ENT surgeon who deals with oncology patients should be familiar with the management of such complications.

This book reviews, for the very first time, the causes of, and treatment options for, complications after surgical voice rehabilitation using voice prostheses.

The authors, all with many years' experience in this field and with considerable involvement in developing treatment strategies, offer a comprehensive, practice-oriented review of the current state of knowledge on this issue and thereby provide a valuable guide for the management of complications – one that should be available in every ENT clinic.

Ulm, January 2017

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1. Introduction

1.1. Epidemiology

With an estimated annual incidence of over 135,000 people worldwide, squamous cell carcinoma of the larynx accounts for approximately 2% of all malignant tumours. In the United Kingdom, the incidence of new cases was 2315 cases in 2013, while in the USA 13,430 new cases of the disease are expected in 2016. In Germany, about 4000 patients develop laryngeal cancer each year.

Males are affected about 5 times more often than females. The peak age is between the ages of 55 and 75 with a median age of 65 years. The German Cancer Registry currently assumes an absolute survival rate of 58% for all laryngeal cancers.

Besides chronic alcohol and tobacco consumption as the main risk factors, viral infections, malnutrition, environmental influences, occupational exposure to harmful substances, a genetic predisposition and gastro-oesophageal reflux are considered to be causal factors[1-4]. Males are affected 5-7 times more often than females. The peak age is between the age of 50 and 60[1,5].

1.2. Treatment approaches in laryngeal cancer

In terms of treatment, depending on the tumour spread and site, laser therapy, radiotherapy or combined chemoradiotherapy are possible, as well as open surgical techniques such as partial or complete resection of the larynx. Surgical tumour removal preserving the larynx is, as a rule, only possible if there are small or moderately sized category T_1 or T_2 tumours.

Larger tumours are treated by complete laryngectomy or combined chemoradiotherapy. In the last 10 to 15 years, there has been a marked increase worldwide in organ-preserving chemoradiotherapy, at the same time as a decrease in laryngectomies. A recent long-term study indicates, however, that organ preservation is not possible in many patients because of a permanent tracheotomy and/or non-functioning larynx. On the other hand, recent studies show a survival benefit for the combination of laryngectomy and postoperative radiotherapy for large laryngeal cancers over organ-preserving chemoradiotherapy. Moreover, in the event of failure of primary chemoradiotherapy, salvage laryngectomy is associated with a greatly increased risk of complications in relation to severe disorders of wound healing.

Consequently, when giving information to affected patients, the pros and cons of the possible treatment options need to be specifically weighed up. As a result, such far-reaching treatment decisions require an interdisciplinary approach, which is readily achieved in tumour boards consisting of head and neck surgeons, radiotherapists, medical oncologists, pathologists and radiologists.

1.3. History of laryngectomy

The first total laryngectomy was performed by Theodor Billroth in 1873 in a case of laryngeal cancer[6]. The operation technique at that time involved mobilising the oesophagus into the suprajugular region and incomplete pharyngeal closure and led to a very high mortality rate of about 50% because of the very high aspiration rate[7]. Through the introduction of complete pharyngeal closure by Gluck, Zeller and Sorensen in 1894, the mortality rate was greatly reduced and the percentage of long-term cures was significantly increased[6,7]. This surgical technique involved bringing the trachea to the surface and closing the pharynx using a vertical, horizontal or T-suture technique and is still used today.

While up to a few years ago, oncological points of view still predominated and were essentially focused on a curative oncological approach, the last years have seen the development of a holistic standpoint. This initially concerned voice rehabilitation with social reintegration through restoration of the ability to communicate and is now also becoming increasingly important in the field of pulmonary and olfactory rehabilitation.

1.4. Consequences of laryngectomy for the patient

A complete removal of the larynx has profound consequences for a patient. Since laryngectomy involves the separation of the upper airway from the lower airway, it not only implies a loss of the voice organ but also leads to chronic lung problems such

as increased coughing, mucus production and expectoration. There is loss of the patient's own voice but also disconnection of the nasal and pharyngeal segment of the lower airways.

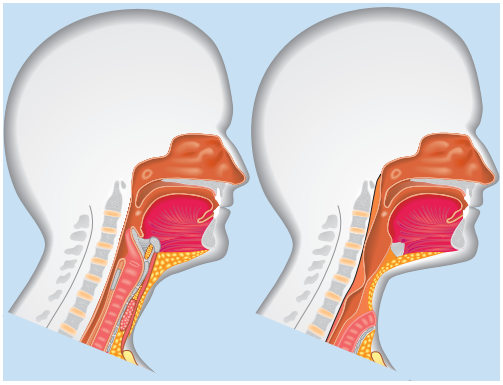

Figure 1.1: Anatomy of the upper aerodigestive tract before and after laryngectomy with complete separation of the airway and digestive pathway.

1.4.1. Loss of voice

The possible social isolation associated with loss of the voice is reported by many patients faced with the diagnosis of laryngeal carcinoma and option of total laryngectomy as the worst imaginable consequence of such an operation. Limitation of the ability to communicate and restriction in terms of social environment consequently determine the first discussions with affected patients. As the voice continues to be a crucial individual feature of a person, loss of an individual's voice is also perceived as partial loss of identity. Closure of a tracheostoma during phonation using a finger represents a form of stigmatisation for many patients[8]. Unlike other prosthetic measures, for example after loss of a limb, the disability is not concealed, rather the patient is forced to draw attention to the missing larynx with their finger.

1.4.2. Loss of conditioning of inspired air

Because of the complete separation of the upper and lower airway after laryngectomy, there is frequently impairment of lung function. The absence of conditioning of inspired air causes irritation of the bronchial mucosa, increased coughing, excessive sputum production and incrustations in the region of the trachea[9-12]. In the medium term, there are changes in the ciliary epithelium of the deep airways in the form of metaplasia with loss of cilia and greatly impaired transport capacity[13]. Physical and psychological performance capacity decrease as a result[8-12,14-19]. Affected patients complain of tiredness and sleeping problems as well as impairment of the sense of smell and taste. Patients often report reactive depression with consequent restriction of social contacts[9,11,14,15,17,19-22].

1.4.3. Loss of the sense of smell

The lack of nasal air flow is responsible for the impaired sense of smell after a laryngectomy. Most healthy individuals smell "passively" via nasal breathing. This is no longer possible after a laryngectomy. Only a few laryngectomised individuals can divert air onto the olfactory epithelium using special sniffing techniques. As an intact sense of smell is not just important for anticipating food and determining taste but also has a warning function (smelling gas and smoke), olfactory rehabilitation after laryngectomy should be strived for. Viewed overall, loss of the ability to smell leads to quality of life being additionally compromised[23,24].

1.5. Possibilities for voice rehabilitation

As the priority for many patients above all is loss of the organ responsible for voice production and thus the reduction in the ability to communicate, total laryngectomy was early on associated with attempts at voice rehabilitation.

A distinction is made here between surgical and non-surgical techniques, the pros and cons of which will be dealt with below.

1.5.1. Oesophageal voice

In 1900, Georg Gottstein described the advent of the oesophageal voice for voice rehabilitation after laryngectomy, which went on to become the standard method in the following decades[7]. In this technique, approximately 80 ml of air is swallowed into the upper part of the oesophagus, which serves as an air chamber for voice production. The mouth of the oesophagus, made of thyropharyngeus and cricopharyngeus, assumes the function of the tone generator (neoglottis). A base tone with an average frequency of 50-64 Hz is produced through vibration[25].

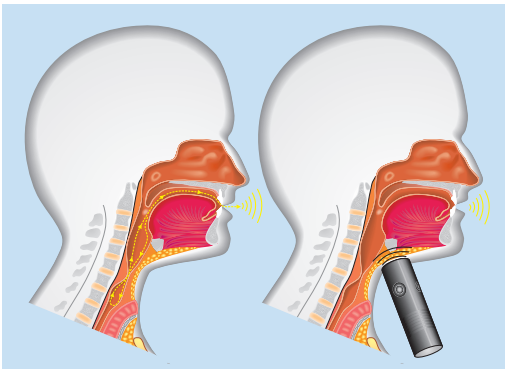

Figure 1.2: Principles of the esophageal voice (left). Principles of voice production with an electrolarynx (right).

The oesophageal voice makes speaking possible without the need for a finger. Both hands can be used while speaking and there are no complications from implanted foreign bodies. However, learning oesophageal speech takes a lot of time and has a much lower success rate compared with other voice replacement techniques. Only about 60% of all laryngectomised patients are able to learn oesophageal speech, and only 30% of affected individuals are able to communicate well with this technique[26,27].

Furthermore, oesophageal voice is inferior to the prosthetic voice in relation to parameters of phonation, such as voice pitch, voice range and understandibility[26-29].

The technique is nevertheless an alternative for patients in whom surgical voice rehabilitation is not possible and learning the oesophageal voice as a back-up method continues to be recommended for all surgically rehabilitated patients.

1.5.2. Electronic speaking aids

Using electronic speaking aids, such as the electrolarynx, the muscles of the neck or floor of the mouth are made to vibrate via an external vibrator. Phonemes can then be formed through producing resonance and narrowing within the region of articulation (oral cavity and throat)[26]. However, a hand is always needed for voice production using this method. The voice has a tinny, mechanical sound which can be modulated to only a very limited degree because of the specified frequency of the vibrator.

1.5.3. Surgical techniques for voice rehabilitation

As early as 1873, Karl Gussenbauer, a colleague of Theodor Billroth, developed a speaking cannula for the first laryngectomised patients. Foulis used similar constructions in Great Britain in 1874[6,7]. However, these speaking cannulae required the creation of a wide tracheo-oesophageal puncture, which was associated with a huge risk of aspiration and greatly increased morbidity. This form of voice rehabilitation was consequently abandoned again relatively quickly. Up until the 1980s, voice rehabilitation was almost exclusively in the form of the oesophageal voice.

The last three decades have seen the further development of techniques for surgical voice rehabilitation after laryngectomy. The basic concept of a valve-like communication (fistula) between the trachea and oesophagus has, however, been retained in all techniques.

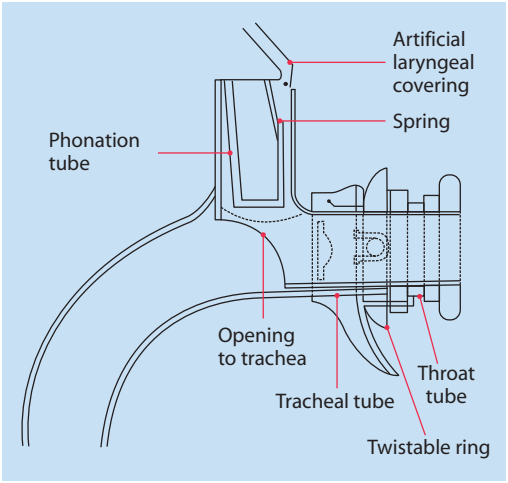

Figure 1.3: Voice rehabilitation by means of a speaking cannula designed by Gussenbauer and Billroth in 1873.

The key advantage of this prosthetic mechanism compared with oesophageal speech is that the entire lung volume of about 3000 ml is available for phonation. Longer speaking periods, a more powerful voice and greater voice volume result. Furthermore, speaking via a tracheo-oesophageal puncture is much easier to learn, the voice sounds more natural and rehabilitation is more successful[28].

Surgical techniques without a prosthesis

Use of a tracheo-oesophageal shunt to take advantage of the lung volume for phonation was revived once again by Gutmann in 1931. He reported a patient who had developed a tracheo-oesophageal fistula[7]. Gutmann, who applied this procedure to his patients using diathermy, stopped these experiments after a few attempts, however, because of severe aspiration. The idea of a tracheo-oesophageal shunt continued to be pursued by many ENT surgeons in subsequent years, however, and in some cases was implemented with a good rehabilitation outcome.

The procedures developed by Staffieri and Asai represented the start of modern methods of voice rehabilitation[30,31]. While both procedures allow a satisfactory voice result to be achieved, they have since lost their importance because of the considerable risk of aspiration[31].

In 1994, a technique was introduced in the form of the Maier and Weidauer procedure[32], a refinement of Asai's technique, which removed the problem of aspiration to a large extent. Using a flap of muscle fascia from the pectoralis muscle and strip of mucosa from the hypopharynx, a speaking fistula is formed which opens laterally and comparatively high up, i.e. below of the lower pole of the tonsil and is compressed during swallowing. However, this technique is only suitable for laryngeal tumours that can be resected with preservation of sufficient pharyngeal mucosa. In 1984, Ehrenberger described a method in which a jejunal segment was transplanted like a siphon between the pharynx, trachea and oesophagus using a microvascular technique[33]. In 1994, Remmert et al. reported a modification to further reduce the risk of aspiration by increasing the jejunal siphon using a loop of digastric muscle[34]. Hagen et al. published the technique of laryngoplasty in 1990. In this method, a microvascularised radialis flap, strengthened with a piece of septum cartilage, is used to form the neo-epiglottis [35].

Ultimately, however, none of the purely surgical voice shunt procedures became established, due to the mostly very difficult surgical techniques, greatly increased operating times and decreasing success of rehabilitation long term as a result of puncture tract stenosis. Moreover, patient morbidity is considerably increased through the extensive surgical operation[36]. Thus, surgical voice rehabilitation procedures using so-called voice prostheses represent a good alternative.

Surgical techniques with voice prostheses

The idea of preventing aspiration symptoms in the context of creation of a tracheo-oesophageal shunt through a valve-like placeholder was rediscovered by Mozolewski in 1972. He described the use of a polyvinyl tube, measuring 5 mm in diameter, which was made into a simple one-way valve using a polyethylene film of 0.007 mm thickness[37]. Mozolewski was also the first to create a tracheo-oesophageal puncture in the context of secondary puncture with retrograde insertion of a prosthesis[38]. In 1979, Singer and Blom developed a voice prosthesis with a duckbill valve and in 1982 published the first two-year experiences[39]. Modifications then led to the development of an indwelling voice prosthesis.

In Europe, the development of voice prostheses began at the start of the 1980s with the Panje prosthesis, the Groningen prosthesis, the Hermann prosthesis and the Provox® prosthesis system[40-44].

1.6. Value of voice rehabilitation with voice prostheses

Voice rehabilitation with voice prostheses also became quickly established in the United States as well as in the UK and Netherlands. As early as the mid-1990s, between 70% and 80% of patients in these countries were managed using this technique. In Germany, only about 15% of laryngectomised patients had voice prostheses at that time. The majority of patients were rehabilitated using purely surgical techniques or by learning the oesophageal voice with moderate success[35]. It has only been in the last twenty years that there has also been a change in thinking in Germany as well – the figure for patients with voice prosthesis is now about 80%.

The advantage of this technique is based on the one hand on a simple operation technique with few complications and which lengthens the total operating time to only a minimal extent, and on the other the rapid success of rehabilitation, which makes phonation possible after just a week postlaryngectomy. The success rate for a readily understandable voice is 90%[7,28, 44-55].