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A Historical Perspective on Surgical Speech Rehabilitation

DONALD P. SHEDD, MD

Over the years there have been a number of approaches to restoration of speech after total removal of a larynx. A review of the history of this field provides interesting examples of human ingenuity. Esophageal speech and the electrolarynx were the dominant methods for many years. The development of surgical approaches to speech rehabilitation has been a fascinating era in the history of the treatment of laryngeal cancer. Some of the early efforts involved rather complex operations or appliances. In recent years the introduction by Singer and Blom of the tracheoesophageal puncture method provided a simple and dependable approach. There are, however, some potential complications and problems that the surgeon and the patient must understand. It is probable that the future will see more and more patients undergoing tracheoesophageal puncture, some at the time of the laryngectomy and some as a second procedure.

Efforts to restore speech to patients after laryngectomy are a fascinating chapter in the history of medicine, and understanding the past record of such endeavors is of great importance. This presentation reviews past efforts and addresses some questions concerning the present status of postlaryngectomy speech rehabilitation.

HISTORICAL BACKGROUND

In an effort to put the history of this subject into some order, one can ask the question: What are all the possible ways of producing speech after a laryngectomy? The answer is that all the possibilities can be divided into electronic methods, pneumatic methods, and electromechanical methods. The last will not be covered because at present electromechanical methods are still in the experimental stage in the laboratory of Dayal et al of Toronto.[1] The others need to be considered in detail. The electronic methods can be divided into those that are surgical and those that are not.

Electronic Methods

The latter category includes the various transcervical devices, which tend to produce speech of monotone quality, as do the peroral instruments. There have been recurrent efforts over the years to produce intra-oral appliances, an example being one offered by the Xomed Company, which had two switches to be controlled by the tongue.

There are two surgical electronic methods,

From the Department of Head and Neck Surgery and Oncology, Roswell Park Memorial Institute, Buffalo, New York.

Address correspondence to Donald P. Shedd, MD, Department of Head and Neck Surgery, Roswell Park Memorial Institute, 666 Elm Street, Buffalo, NY 14263.

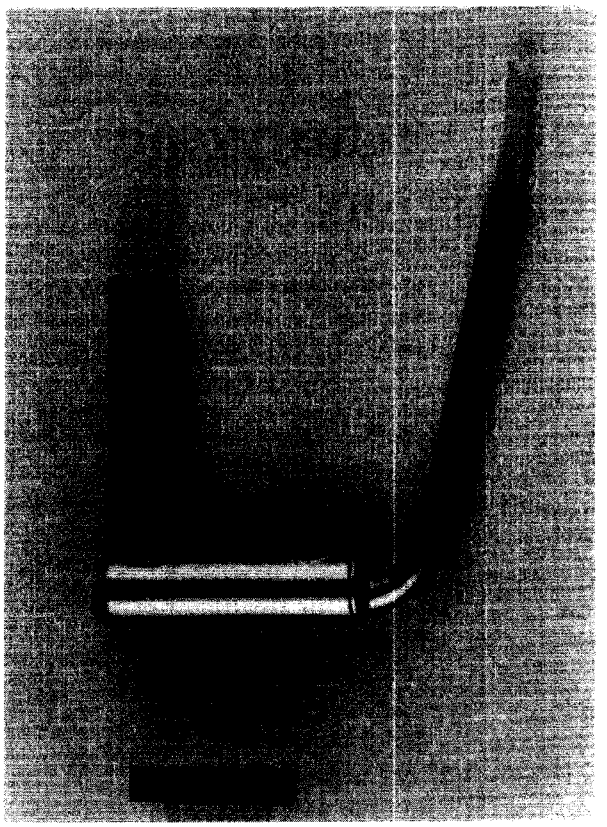

Figure 1. A stoma-to-mouth speech appliance, a device containing a harmonica-type reed.

the concept of transfistula transmission of electronic sound having been tried in the past by Goode.[2] The work of Griffith et al[3] and Young et al[4] on implantation of electronic sound sources has been extended to humans and seems to hold promise.

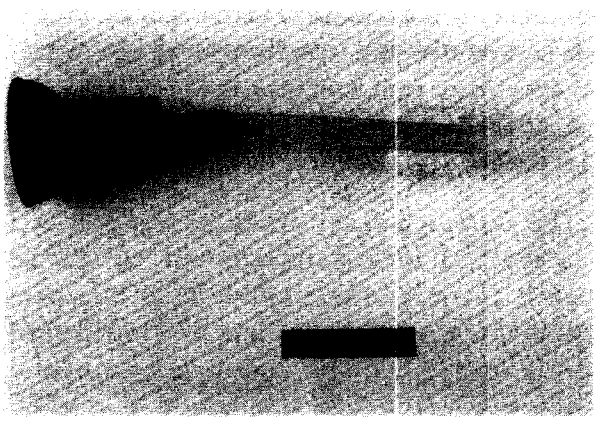

Figure 2. A stoma-to-mouth appliance from Japan, containing a rubber-membrane type of vibrating device for sound production.

Pneumatic Methods

The pneumatic methods can be divided into those that use pulmonary air and those that use nonpulmonary air. Of the latter, there are three, and two of them—buccal and pharyngeal speech—are not acceptable to speech pathologists. Buccal speech depends on trapping air in the cheek pouch and has low intelligibility. Similarly, pharyngeal speech traps air farther back at the faucial level and also has poor quality.

Esophageal speech, probably the best of all methods, has been around since before the first laryngectomy. Unfortunately, a large number of patients are unable to master it, thus producing interest over the years in alternative methods.

The pulmonary air methods can be divided into nonsurgical and surgical techniques. The only nonsurgical method is that of the old stoma-to-mouth reed, a device that enjoyed considerable popularity before the advent of the electrolarynx (Figs. 1 and 2).

The surgical approaches are divisible into those that do and those that do not use an appliance. In considering these, one can designate some historical channels named after the persons with whom the approaches or the concepts involved originated. These follow a conceptual rather than a temporal sequence and are marked as the Asai channel, the Billroth channel, the Conley–Briani channel, and the ice pick channel.

Asai Channel

The original Asai operation required three stages,[5] but worked well, as verified by Miller.[6] Montgomery[7] reduced the number of surgical stages to two. McGrail and Oldfield[8] reduced the number of stages to one by using a deltopectoral flap to connect the

trachea to the pharynx. Komorn[9] and Calcaterra and Jafek[10] used a direct fistula made from the esophageal wall to connect the two viscera.

It is important to note that many of these methods came up against the black beast of surgical speech rehabilitation—the problem of leakage of saliva and ingested material into the trachea. One attempt to solve this difficulty was the effort of Stallings.[11] Working with a Komorn-type fistula, he attempted to control leakage by constructing a sphincter using a tendon graft under the fistula, the graft being attached by both ends to the mandible. Tipping the head back in swallowing would tighten the tendon and was meant to close the fistula.

Staffieri[12] formed what he called a phonatory neoglottis by draping anterior pharyngeal wall over the end of the cut trachea at the time of laryngectomy and making a slit in the draped portion. He had a number of successful results, and his methods became popular in Europe.

Arslan and Serafini[13] attempted restoration of function after laryngectomy by bringing the first tracheal ring up to the level of the epiglottis. In some of their patients, they even attempted to carry out tracheal extubation, thus striving for total rehabilitation. There were, however, severe respiratory problems in these patients.

Finally, Amatsu[14] devised a technique using a portion of tracheal wall to produce an inclined fistula from trachea to esophagus. The importance of this work is its relation to the later efforts of Singer and Blom.

Billroth Channel

As early as the first laryngectomy, Billroth had his associate Gussenbauer[15] devise an appliance for speech containing an extrinsic vibrator, a reed, for sound production. Others working in this channel all followed the reed concept. Brown[16] used an ear speculum and a standard musical pitch pipe with successful production of voice.

As so often happens in history, ideas kept recurring. Taub and Spiro[17] used reeds again in the 1970s. They were aided by the fact that the age of plastics greatly facilitated the fabrication of appliances. The Roswell Park Memorial Institute (RPMI) group also studied appliances with extrinsic vibrators.[18]

Conley–Briani Channel

The next channel is named for John Conley[19] of New York and A. A. Briani[20] of Italy, both of whom, at about the same time, worked on methods to route tracheal air into the esophagus through external appliances. Briani did so with a plastic device with valves, and Conley used a tracheostomy tube with a side arm leading into the fistula. Taub and Spiro,[17] after their earlier work with reeds, evolved a second device that was marketed commercially, called the *voicebak.* This had an ingenious respiratory valve included, an idea that turned up years later in the work of Singer and Blom.

The RPMI group[21] attempted a similar approach, called the air tunnel method, with devices made by the department of maxillofacial prosthodontia. Sisson et al[22] described a technique that included a trimodal respiratory valve—one that stayed open for breathing, closed for speaking, and prolapsed when the patient coughed. Edwards[23] also devised a similar method and applied it to a number of patients with modest success.

Ice Pick Channel

The final historical development, the ice pick channel, derives its name from the instrument used by an early patient, reported by Guttman.[24] The patient, heating his ice pick red hot, made his own fistula. He kept the tract open with a goose quill, and the vocal result was excellent. Reference was made earlier to the work of Amatsu, and it was in trying Amatsu's procedure that Singer and Blom[25] came up with their tracheoesophageal puncture (TEP) method. Initially they

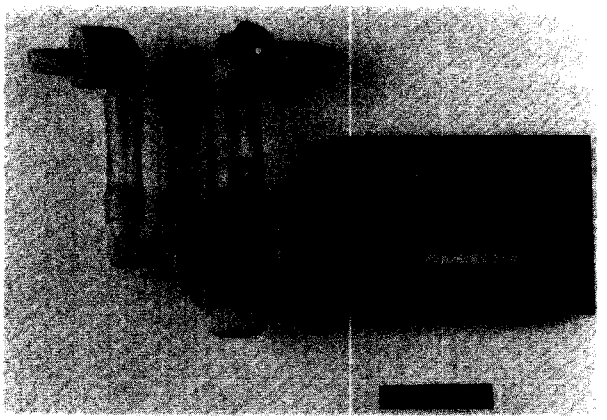

Figure 3. Comparison of two types of speech appliances. The one on the left was designed to route air from the tracheal stoma into a pharyngocutaneous fistula. The one on the right was designed for use in a tracheoesophageal fistula.

used homemade duckbill valves, but later improved versions were marketed commercially. Several modifications have appeared, one being that of Panje et al,[26] who placed the fistula lower and used a different appliance for better retention. Henley-Cohn et al[27] made another modification, as did Shapiro and Ramanathan,[28] and each of these was designed to fulfill certain requirements. Singer and Blom deserve credit not only for their initial idea but also for the subsequent phases of their work. After the Amatsu operation led them to the TEP with a duckbill prosthesis, they studied the percentage of patients who did not have good voices after a puncture and concluded that an element of pharyngeal spasm was a factor. They first approached this problem with a myotomy of the constrictor musculature and later with a neurectomy of the pharyngeal plexus. They also studied not only the role of a TEP done months or years after a laryngectomy but also the potential for success if the puncture were done at the time of the laryngectomy, which can be called a *primary puncture.*

It is impressive in this record of achievement to see the many ways in which human ingenuity has been applied to the solution of a biologic problem, alaryngeal aphonia. Looking back on this bit of surgical history, one can draw some conclusions. First, it is impressive in the history of science to visualize the evolution from moderate complexity to extreme simplicity, exemplified in the comparison of the early Taub device with the current Singer–Blom appliance (Fig. 3). Second, it is important to point out that all that has been done has centered on development of a connection from the airway to the alimentary tract, with a valving mechanism, made either of artificial materials or of natural tissues. At the moment it appears that the artificial materials are better. Third, it is of interest to note that many of the earlier methods left some mark for later rediscovery. For example, the old direct puncture technique used by Guttman's ice pick patient in 1935 was abandoned until its rediscovery by Singer and Blom. They had the persistence to find that a short direct fistula was a manageable situation if one could devise a good enough valve, and this they did, first with a crude prototype, and later with their improved version, making obsolete most of the more complex devices used by other workers.

LATER EVENTS

A workshop on surgical speech rehabilitation took place at the RPMI in 1978. Among the surgeons who participated were Bailey, McConnel, Singer, Stallings, Taub, Shedd, and Sisson of the United States, Staffieri of Italy, Vega of Spain, and Edwards of the United Kingdom. The speech pathologists included Logemann, Blom, and Weinberg. At this workshop, the participants described their various approaches to the problem of restoration of speech after laryngectomy. The results of the workshop were summarized in a book published in 1980.[29]

At RPMI a number of approaches were used over the years. The *reed fistula method* was used for patients who had undergone pharyngolarynectomy. A procedure called

the *air tunnel method* was used for patients after standard laryngectomies. A small number of Staffieri operations were done, as were a small series of TEPs. Each method taught some lessons. It was learned that there are some fascinating biomedical challenges in surgical speech rehabilitation. Surprisingly good voices could be produced when tracheal air was routed into the pharynx. The experience with TEP was favorable, although there were two patients who lost their fistulas, a 25% failure rate. The problems were small, with delay in voice development occurring in one highly motivated patient who finally, after several months of persistence, overcame an initially spastic state of his pharynx and developed good speech. Loss of the appliance down the trachea occurred after one of the wings of the prosthesis had been cut off to facilitate fitting in a patient who had a very deeply placed stoma. It was concluded that TEP is a dependable method with few problems, but that one needs to be flexible about which appliance to use of the several available. A considerable time investment is needed on the part of the surgeon and the speech pathologist. The patient's role is a major one, in that the patient must have the ability to work hard toward successful rehabilitation of voice.

CURRENT STATUS

Statements about the current status of the field are easier to make concerning the postlaryngectomy patient than about the patient who has not yet undergone the ablative procedure. One can say that *if* a patient is 6 months postoperation and is not achieving good esophageal speech, and *if* that patient is dissatisfied with the electrolarynx, then the patient should be evaluated for a possible puncture. Motivation is important, and the patient must be intelligent enough to understand the problem. The patient must be dextrous enough to manage the prosthesis, and the stoma must be large enough to accommodate the device. An air insufflation test gives some prediction of voice quality and is recommended as a factor in the decision about a possible pharyngeal myotomy. Endoscopy to rule out the presence of a recurrence or new primary lesions should not be forgotten. A patient who passes all of these criteria is a reasonable candidate for TEP.

The question of doing the TEP at the time of the laryngectomy (primary puncture) is a more difficult one.[30] There is a wave of enthusiasm for this approach. There are clear advantages to avoiding a period of voicelessness, but there are problems associated with performing the puncture in conjunction with a laryngectomy. A patient who has had a laryngectomy has a number of problems to face without adding a fistula to the difficulties.

Some of the initial reports do describe good results with primary punctures, and further experience should decide whether this is the method of choice in selected patients.

COMPLICATIONS

As with any operation, the possibility of complications and problems exists, but these are relatively infrequent with TEP.

One can consider complications and problems in relation to the TEP itself and in regard to the myotomy. As far as systemic complications are concerned, the author has seen one instance of pneumonitis occurring soon after the puncture, and it was of moderate severity. Stomal narrowing in the early postoperative period can occur from simple postoperative edema or from infection around the puncture site. Major tracheoesophageal fistulization has occurred and can result when a rigid tracheal tube is used in conjunction with a rigid stent in the fistula. It is a major complication but a preventable one. Loss of the prosthesis down the

Table 1. Commercially Available Voice Prostheses

Company	Product
American V. Mueller	Voice prosthesis
Bivona	Voice prosthesis
	Low-resistance prosthesis
	Periscope prosthesis (Shapiro)
	Colorado prosthesis
Storz	Henley-Cohn prosthesis
Xomed	Panje button

trachea can occur with certain appliances and again should be avoidable. The problem of loss of the fistula can occur in an inattentive patient who does not follow instructions well. Leakage around the prosthesis may require cauterization, and leakage through the device is an indication for replacement because of a worn valve. The problem of inadequate voice is believed to be from pharyngeal spasm in some patients, and, for this, pharyngeal myotomy is recommended. All in all, the complication rate with current TEP is acceptable.

As far as complications from the pharyngeal myotomy are concerned, Singer[31] reports a 9% incidence of fistulas in patients in whom myotomy is done at the time of laryngectomy, indicating that these two operations should not be combined.

A simplified statement on the current status of surgical speech rehabilitation has been given, but some specific questions need clarification. Singer and Blom have given us some answers, but these may need verification by other investigators. The questions can be grouped under these headings: questions pertaining to selection of patients and the operation itself, questions relating to the choice of appliance, and questions relating to the matter of whether to perform a primary TEP. Finally, there are items relating to the overall results of surgical speech rehabilitation across the country as a whole.

In regard to selection of patients, there is a question as to what is the smallest size stoma through which the puncture can be done. If a stoma is too small, what is the best way to enlarge it?

In respect to intelligence and motivation, how can we best assess these qualities to know with reasonable certainty whether a given patient qualifies?

Regarding the insufflation test, Blom et al[32] have published an article on standardizing the test. If a patient fails preoperatively to achieve 8 seconds of phonation on insufflation, that patient should be considered for myotomy at the time of the puncture. Must this rule be followed for all patients?

In regard to the operation, recommendations as to fistula size have varied since the procedure was first described, and physicians now need to know what is truly the optimal diameter. A law of physics pertains, Poiseuille's law, which describes volume of flow in a tubular system. Poiseuille's law states that the volume flow in a tube is directly proportional to the pressure drop along the length of the tube and to the fourth power of the radius of the tube and inversely proportional to the length of the tube and the viscosity of the fluid. The important item to note is that the radius of the tube is to the fourth power, indicating that small increases in diameter of a fistula can result in great increases in air flow. Such increases mean a stronger voice, so that efforts to maximize fistula size are a valid long-term goal.

There are questions about the possible use of pharyngeal plexus neurectomy as a safer alternative to myotomy in patients with spasm: Is it dependable, and how is it best done?

There also are questions about the appliances now available, some of which are listed in Table 1. It is possible that one is truly best, but it may be that each one has its indications and that judgment is needed for selection. The original Singer–Blom appliance had two wings, and the latest model

has only one. The Panje device is held in place by two flanges. The Shapiro appliance is completely self-retaining and is useful when stoma size is borderline. Henley-Cohn's contribution is meant to be in position for long periods and can be cleaned in place rather than removed. One can see that there is a wide choice.

A question exists about the stoma valve, a device designed to eliminate the need for digital occlusion of the stoma in speaking. What is the success rate in its use? Should some patients have the puncture done at the time of laryngectomy, and if so, what are the selection criteria? More clinical experience is needed to answer this. Finally, what are the overall success rates, and how do they differ from those of Singer and Blom, and what are the complication rates? This is information needed for truly informed consent from prospective patients.

In looking ahead, one can see some areas of reasonable prediction and two areas of hope. It is expected that there will be increasing numbers of secondary punctures done, that is, TEPs sometime subsequent to the laryngectomy in patients who are unsuccessful in developing esophageal speech. There will probably also be more primary punctures done at the time of laryngectomy, and time will tell whether this is a good route to follow. It is hoped that there will be development of centers for this kind of surgery, because only institutions with a large volume of patients can provide answers to some of the important questions.

Finally, one can hope that some major organization concerned with speech rehabilitation will set up a nationwide study to determine true speech results, complications, and degrees of patient satisfaction; all are vital in addressing the long-term future in this field.

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