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Main Article

Managing problems with tracheoesophageal puncture for alaryngeal voice rehabilitation

O A Albirmawy, MD, M N Elsheikh, MD, M E Saafan, MD, E Elsheikh, MD*

Abstract

Objectives: The tracheoesophageal puncture (TEP) technique and the insertion of its associated voice prostheses may give rise to adverse events. We present our experience with this technique, paying special attention to the incidence and management of these adverse events.

Study design: A retrospective clinical analysis was undertaken.

Methods: Seventy-five laryngectomized patients underwent TEP for voice restoration. They were divided into two groups: group one, 43 patients with secondary TEP; and group two, 32 patients with primary TEP. Patient medical records were reviewed for data on the incidence, management and outcome of adverse events encountered during patients' follow up.

Results: Problems that arose in the patients were itemized as either early or late. The same patient could develop one or more problems in either group. The management of these problems, concerning the creation and maintenance of the TEP and associated prostheses, was noted. In group one, results were initially favourable in 91 per cent of patients and still positive in 81.4 per cent after three years. In group two, early results were favourable in all patients, and only two patients asked for late elective closure of the TEP (with a success rate of 93.7 per cent).

Conclusions: Via an intensive and multidisciplinary approach to problems, most of the inevitable adverse events could be solved adequately, minimizing the discomfort of patients who had undergone laryngectomy and indwelling voice prosthesis insertion.

Key words: Speech, Alaryngeal; Trachea; Otolaryngologic Surgical Procedures; Laryngectomy

Introduction

In patients with laryngectomy, the implantation of voice prostheses is currently the vocal rehabilitation method of choice. Voice prostheses are one-way valves inserted into a surgically created tracheoesophageal fistula (TEF), which allow air to be shunted from the lungs and trachea into the oesophagus to generate speech. The tracheoesophageal puncture (TEP) technique and insertion of its associated prosthetic valves are not always free of problems. The otolaryngologist may be called to diagnose and resolve many related problems. Some of these are simple, whereas others may challenge even the experienced clinician.

Few reports in the literature have carefully evaluated the complications and adverse events associated with prosthetic vocal rehabilitation. These may occur in the initial phase of rehabilitation or years later, and include: leakage through or around a tracheoesophageal voice prosthesis;[1,2,3] immediate or delayed aphonia or dysphonia;[4,5] small or large tracheostoma;[6,7] granuloma formation;[8] excessive tracheostoma mucus discharge;[8] problems with elective closure of the TEP;[9] excessive stomach gas;[4,5] hypotonic and wet voices;[10] hypersensitive gag; and hypersensitive cough.[11]

We here report our experience with consistent use of TEP and indwelling voice prostheses for vocal rehabilitation after total laryngectomy. We reviewed our records for an unselected cohort of patients, paying special attention to the incidence and management of the adverse events inevitably encountered with this method of vocal rehabilitation.

Patients and methods

Between June 1999 and May 2004, 75 patients underwent TEP for voice restoration at the Tanta University Hospitals and Tanta Cancer Institute. These patients were divided into two separate groups.

Group one included 43 patients (38 men and five women; 35 to 68 years of age; mean age, 51.5 $\pm$ 6.4 years). The interval between total laryngectomy and prosthesis implantation varied from one month

From the Otolaryngology Department, Tanta University, and the, and the *Surgical Oncology Department, Tanta Cancer Center, Tanta, Egypt.
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to one and a half years. Prior to TEP, patients had undergone total laryngectomy with bilateral neck dissection (26 patients), total laryngectomy with unilateral neck dissection (12 patients), or total laryngectomy with partial hypopharyngectomy (five patients). Pre- or post-operative radiotherapy had been undergone by 27 patients (63 per cent). Patients were selected on the basis of their motivation to learn a means of verbal communication. They all underwent a pre-operative barium swallow, pharyngoesophageal radiography and an oesophageal insufflation test (by an adaptation of the method described by Blom and Hamaker,[8] which uses the patient's own breathing apparatus).

Creation of the secondary TEP was performed, according to the method described by Blom, Hamaker and Singer[8,9] in some cases and using the Provox trocar (ATOS Medical, Hörby, Sweden) apparatus in other cases. The TEP required a pharyngeal constrictor myotomy in six cases. The catheter was usually replaced by the Blom–Singer indwelling voice prosthesis 48 hours after the operation, while the Provox 2 voice prosthesis was inserted immediately after the puncture. The patient was then trained in the use and maintenance of the fistula and prosthesis. Hospitalization generally lasted from two to four days after the puncture.

In group two, the surgical team used a primary TEP as the rehabilitative method of choice, for a total of 32 patients (29 men and three women; 43 to 62 years of age; mean age, 52.5 $\pm$ 6.1 years). Procedures included total laryngectomy with bilateral neck dissection (20 patients), total laryngectomy with unilateral neck dissection (eight patients), and total laryngectomy with partial hypopharyngectomy (four patients). Pre- or post-operative radiotherapy was undergone by 14 patients (44 per cent). Particular care was taken with certain aspects of total laryngectomy in the majority of this group: cutaneous incision, stoma construction, sternomastoid incisions, pharyngeal neurectomy, pharyngeal myotomy and hypopharyngeal closure. The Blom–Singer indwelling low pressure and Provox 2 voice prostheses were used in these patients. The demographic and clinical data for the study population are summarized in Table I.

Follow-up periods ranged from eight to 67 months (mean follow up, 36 months). A review of patients' medical records noted the incidence, management and outcome of adverse events encountered during patients' follow up. Any TEP problems were divided into early problems and late problems.

Results

Group one

Thirty-nine of the 43 patients in group one (91 per cent) quickly acquired an intelligible voice using the prosthesis. Of the four unsuccessful cases, sound emission was lacking or inadequate in three patients (who refused pharyngeal myotomy) and problems concerning the fistula (including prosthesis insertion problems) arose in only one patient.

Over a year later, only 35 patients of the 43 were still using the prosthesis. Of the eight patients whose prosthesis proved unsuccessful in the long term, the main reason for failure was inadequate motivation to learn a verbal communication method. Three patients gave up using the prosthesis owing to problems concerning the fistula (maintenance, closure and salivary leakage). Another three patients considered the quality of the tracheoesophageal speech unacceptable. Progressive shrinkage of the tracheostoma obliged one patient to remove the prosthesis. One patient died of cancer less than a year after their prosthesis was implanted. The incidence and type of problems in group one patients are summarized in Table II.

Group two

During follow up, results were generally favorable in group two. Four patients of the 32 developed immediate leakage through the prosthesis. This was noted to be due to distortion of the flap valve to the open position. Two patients developed immediate dysphonia due to airflow-elicited pharyngeal constrictor muscle spasm. Another two patients complained of an over-large tracheostoma which thus could not be occluded by thumb or finger to obtain adequate speech. Four patients developed a hissing or hypotonic voice, while another four noted hypersensitive gag and cough reflexes. Tracheobronchitis developed soon after the operation in eight patients, six of whom developed peristomal cellulitis. Only two patients asked for elective closure of the TEP (6.25 per cent), late in the follow-up period. The incidence and type of

TABLE I

PATIENTS' DEMOGRAPHIC AND CLINICAL DATA

	Group I ($n = 43$)	Group II ($n = 32$)
Age (years; mean $\pm$ SD)	51.5 $\pm$ 6.4	52.5 $\pm$ 6.1
Sex (male/female)	38/5	29/3
Intervention		
TL & bil ND (patients)	26	20
TL & uni ND (patients)	12	8
TL & partial pharyngectomy (patients)	5	4
TEP	Secondary	Primary
Peri-operative radiotherapy (patients)	27	14

SD = standard deviation; TL = total laryngectomy; bil = bilateral; ND = neck dissection; uni = unilateral; TEP = tracheoesophageal puncture

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TABLE II

PATIENTS' INCIDENCE OF EARLY AND LATE PROBLEMS

Type of problem	Group I ($n = 43$)		Group II ($n = 32$)	
	n	%	*n*	%
Early				
Immediate leakage through the prosthesis	4	9.3	4	12.5
Early leakage around the prosthesis	2	4.6	–	–
Immediate aphonia or dysphonia	5	11.6	2	6.2
Tracheostoma too small	6	13.9	–	–
Tracheostoma too large	2	4.6	2	6.2
Excessive stomach gas	3	6.9	–	–
Hypotonic voice	5	11.6	4	12.5
Wet voice	–	–	–	–
Hypersensitive gag	2	4.6	4	12.5
Hypersensitive cough	1	2.3	4	12.5
Tracheobronchial inflammation	4	9.3	8	25
Peristomal cellulitis	4	9.3	6	18.7
Late				
Late leakage through the prosthesis	28	65.1	20	62.5
Late leakage around the prosthesis	7	16.2	2	6.2
Delayed aphonia or dysphonia	7	16.2	2	6.2
Narrowing stoma	11	25.5	–	–
Granuloma formation	10	23.2	6	18.7
Failure of elective closure	2	4.6	2	6.2
Excessive phlegm production	14	32.5	6	18.7
Aspiration of prosthesis	5	11.6	4	12.5

problems in group two patients are summarized in Table II.

Problems and their management

One or more problems arose in all of the patients of this study; some developed early after prosthesis insertion while others developed later. Most of these problems concerned the creation and maintenance of the TEP and the prostheses.

Immediate leakage through the prosthesis was managed by removal of the prosthesis and inspection of its valve for debris and competence of closure, followed by reinsertion and reassessment as the patient drank liquid. For all patients in the study, late leakage through the prosthesis as a result of microbial colonization was treated with oral nystatin suspension thrice daily (Figure 1). Leakage due to the valve reaching the end of its natural life span (i.e. four months to one year) was managed by simply replacing the prosthesis with a new one.

Leakage around the prosthesis was noted to be due in some patients to an over-long prosthesis which moved back and forth within the tract, causing mechanical dilatation. Remeasurement of the TEP and insertion of an exact length prosthesis eliminated such pistoning and provided a circumferential retention collar seal against the anterior oesophageal wall mucosa; leakage stopped immediately or within approximately 24 hours (Figure 2a and b). Leakage continued in some patients from each group despite proper sizing of the prosthesis, correction of malnutrition and controlling of blood sugar levels in diabetics. It was noted that most of these patients had undergone pre- or post-operative radiation therapy, and endoscopic evaluation did not reveal recurrence or primaries in any of these patients. Some punctures responded well to chemical cautery using trichloroacetic acid, while others responded well to gradually decreasing a Foley catheter size to allow shrinkage of the puncture, followed by reinsertion of the prosthesis (Figure 3). In one case,

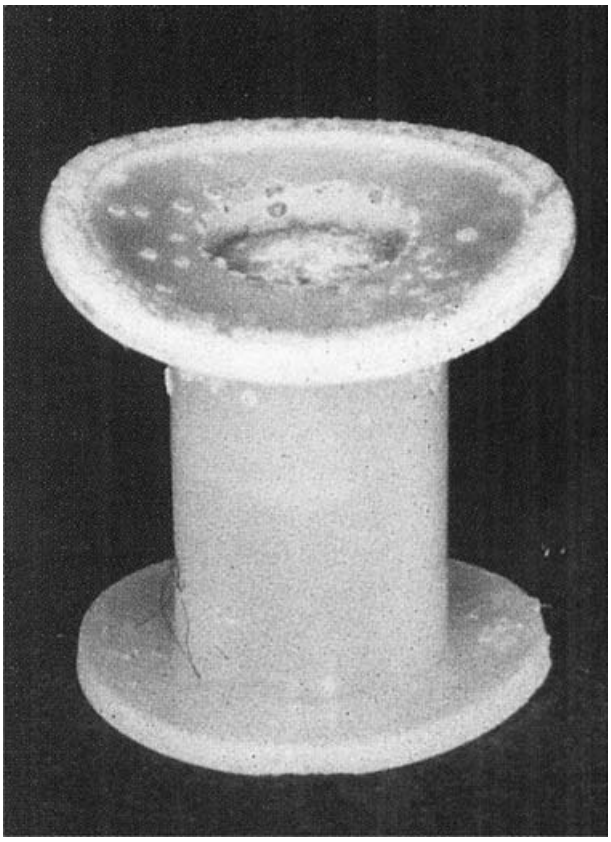

FIG. 1

Microbial colonization filling the prosthesis and distorting its value.

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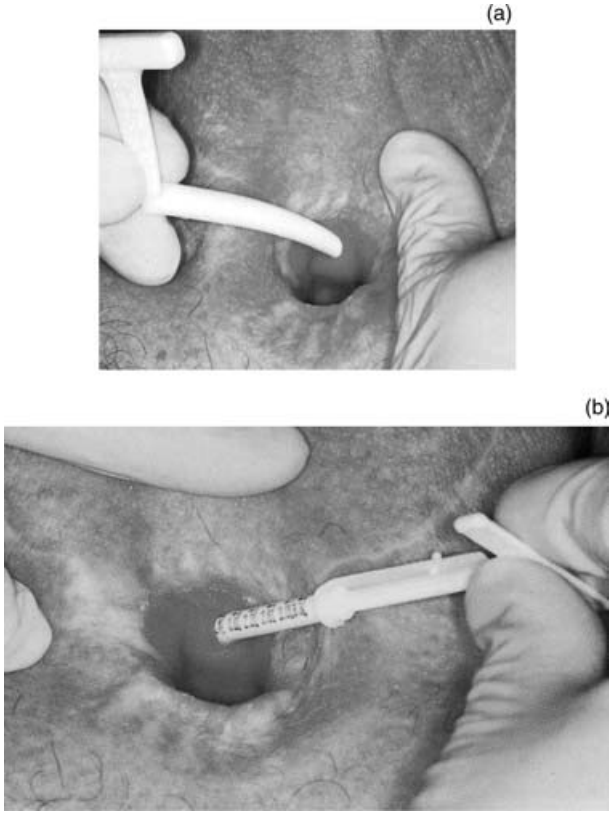

FIG. 2
(a) Cleaning the puncture before measuring its length. (b) Measuring the exact length of the puncture.

the puncture did not respond to cautery and resizing. An appropriate prosthetic solution was to fit a voice prosthesis with a significantly tighter tolerance in the anterior-posterior direction in order to achieve the maximum seal between the retention flange and the anterior oesophageal wall mucosa. Adding a 2 mm silicone sheet securely onto the shaft of the prosthesis shortens its length and snugs the retention flange against the anterior oesophageal wall mucosa (Figure 4).

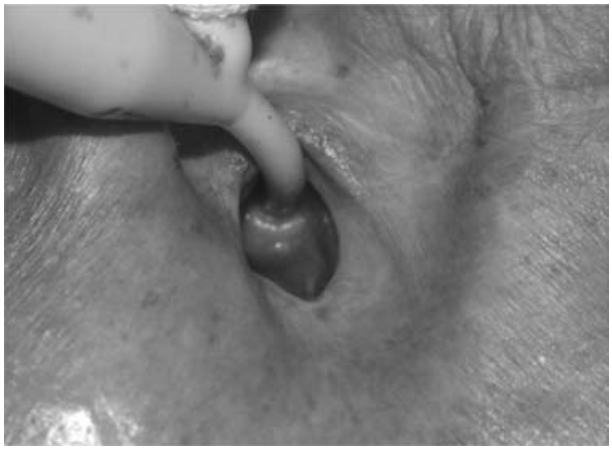

FIG. 3
Down-sizing the puncture by using the smallest Foley catheter.

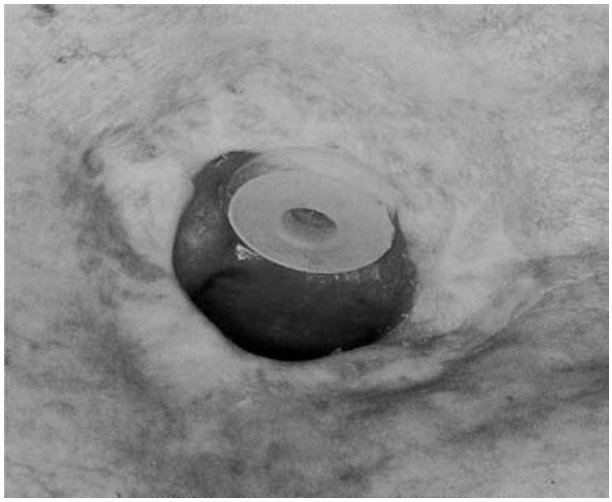

FIG. 4
A silicone shim hugging the distal end of the prosthesis.

Some patients developed immediate aphonia or dysphonia, while others complained of these at a later date. The first step in the management of this problem was to eliminate the voice prosthesis as a causative factor by having the patient attempt to vocalize through an open TEP. Fluent and effortless voicing resulted, which was lost with reinsertion of the prosthesis. In most of these cases, the flap valve of the prosthesis was found to be stuck in the closed position and required gentle deformation of the silicone to open. In other cases, the anterior-posterior dimension of the oesophageal lumen was narrow at the point of prosthesis entry. The solution was to replace the prosthesis with a shorter one or to simply trim off the 2 mm projection of the prosthesis to prevent contact with the posterior oesophageal wall.

Some patients' voices remained effortful, both with and without the prosthesis in place; this problem was caused by forceful finger occlusion against the stoma in some patients and by airflow-elicited pharyngeal constrictor muscle spasm and stricture in others. Hopefully, altering the force with which the stoma was digitally occluded resolved the former situation. Complete spasm or hypertonicity of the pharyngeal constrictor muscles was confirmed by videofluoroscopy during attempted phonation and eliminated by repeated percutaneous pharyngeal plexus blockage with 2 per cent lidocaine. However, pharyngeal constrictor muscle myotomy was required in two cases (Figure 5).

Patients with pharyngeal constrictor muscle stricture demonstrated restricted swallowing and phonation. Repeated endoscopic dilatation was successful in the management of this problem.

Stoma size problems were observed – both over-large (Figure 6) and over-small tracheostomas (Figure 7). A tracheostoma less than 1.5 cm was not adequate to easily and safely accommodate placement and maintenance of a voice prosthesis; such tracheostomas were either serially dilated to accept (at a minimum) a size-nine silicone tracheotomy

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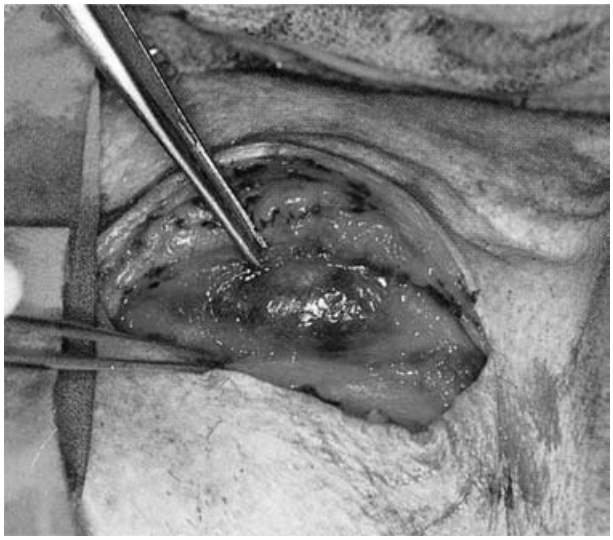

FIG. 5
Secondary constrictor muscle myotomy.

tube or were surgically revised by stomaplasty. When a tracheotomy tube was used, its posterior wall was fenestrated to provide a midline window; this fenestration aligned with the tracheal opening in the voice prosthesis to facilitate unrestricted airflow for tracheoesophageal phonation. Stoma stenosis in irradiated patients was managed prosthetically rather than surgically. Over-large tracheostomas were managed either by two-finger occlusion or by insertion of a fenestrated tracheotomy tube, which reduced the diameter of the opening and provided a surface that could be easily occluded with a finger or thumb.

FIG. 6
A large tracheostoma.

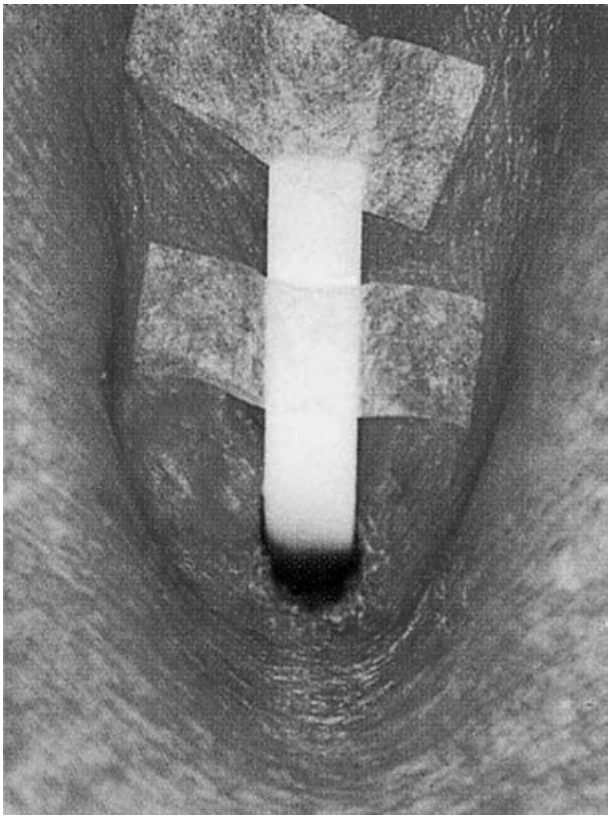

FIG. 7
A small tracheostoma.

A growing circumferential granuloma at the tracheal end of the puncture was observed in some patients (Figure 8). Once observed, the prosthesis was removed and the TEP stented with a 14-Fr rubber catheter and injected with 1 per cent lidocaine

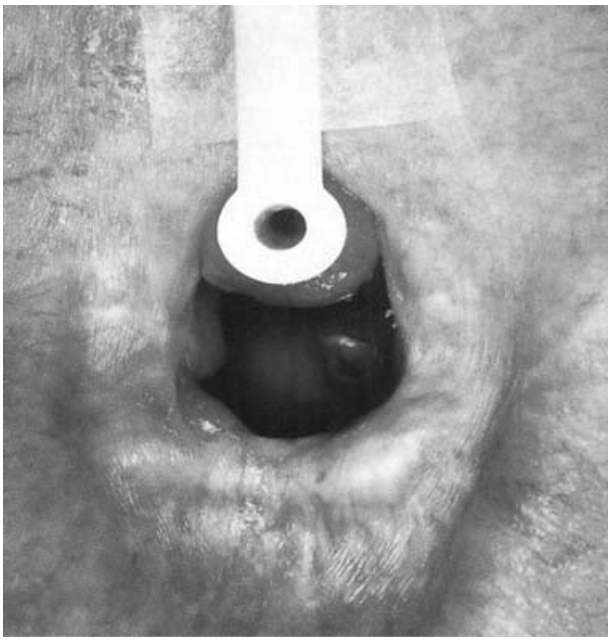

FIG. 8
A circumferential granuloma around the prosthesis.

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with adrenaline. The catheter was gently grasped and removed circumferentially with sharp scissors or a blade. Trichloroacetic acid or electrocautery was used to cauterize the area of excision and the specimen was sent for routine laboratory verification. In histologic terms, this was granulation tissue rich in newly formed blood vessels. The catheter remained overnight; the TEP was then measured and a voice prosthesis reinserted.

Three patients in group one complained of early, excessive stomach gas; videofluoroscopy showed pharyngoesophageal spasm in one patient, stricture in another and hypotonic muscle in the third. Spasm was released by repeated lidocaine injection whereas stricture responded well to repeated dilatation.

A hypotonic, weak voice developed in few patients; all responded well to gentle finger pressure above the stoma, over the pharyngoesophageal muscle. Most of these cases had undergone pharyngoesophageal myotomy or combined myotomy and neurectomy to avoid spasm or stricture, at the time of prosthesis application.

Lidocaine spray was sufficient treatment for most patients who developed hypersensitive gag and cough. The alternative was prosthesis resizing (required by only one patient) to avoid contact with the posterior pharyngeal wall mucosa.

Cases of tracheobronchitis and peristomal cellulitis were managed by systemic antibiotic and local antibiotic ointment around the stoma, together with mucolytics and inhalation of humidified air (Figure 9).

In some patients who requested prosthesis removal (and thus ceased tracheoesophageal phonation), the puncture failed to close spontaneously (Figure 10). Some of these patients had been irradiated and others were diabetic. Diabetes was controlled and a gradually decreasing Foly catheter inserted, down to the smallest size, followed by repeated cautery by trichloroacetic acid to stimulate stoma contraction, during which time a cuffed tracheostomy tube was inserted to avoid aspiration.

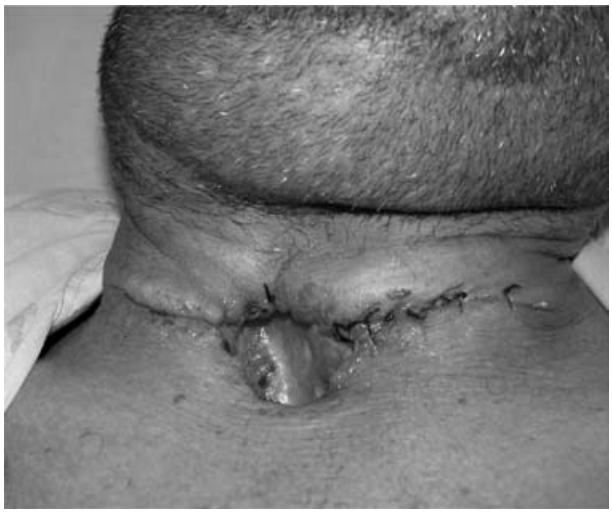

FIG. 9
Peristomal cellulitis and tracheitis.

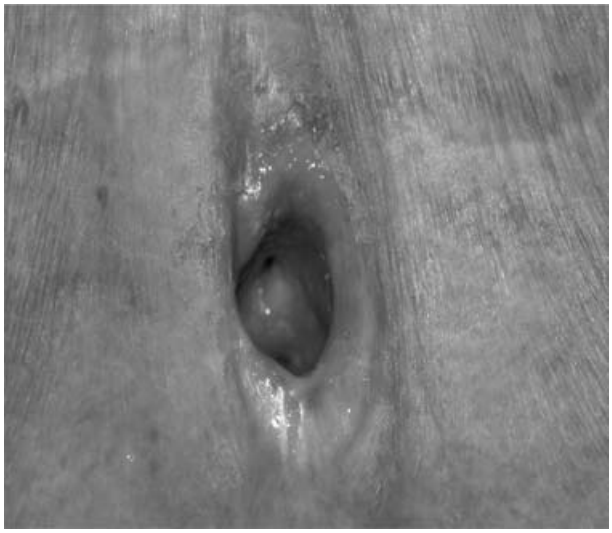

FIG. 10
Resistance to elective puncture closure.

Excessive phlegm production was a major problem due to recurrent closure of the tracheal end of the prosthesis by crusts. The problem was simply controlled by systemic antibiotics, mucolytics and humidified air, together with careful prosthesis maintenance.

Patients who aspirated the voice prosthesis were managed by flexible bronchoscopic removal under local anaesthesia, followed by resizing and reinsertion of the prosthesis.

Discussion

During their rehabilitation, most laryngectomized patients try to use oesophageal speech, however many are incapable of learning this method adequately.[12,13] In the last 20 years, surgical approaches to voice rehabilitation have made considerable progress, following the advent of the TEP technique developed by Singer and Blom.[14] The number of new prostheses on the market confirms interest in this new technique.[15] The fistula for the prosthesis can be prepared either during total laryngectomy (primary rehabilitation) or at a later date (secondary rehabilitation), and there is some debate as to which solution offers the best results.[2,16,17]

In our study, secondary TEP was performed in 43 patients. Results were initially favourable in 91 per cent of cases and still positive in 81.4 per cent after three years of follow up (considered a sufficient interval for final evaluation).[18] Initial failures were generally due to hypertonicity of the pharyngoesophageal tract or to problems with the use and maintenance of the fistula and prosthesis. Inadequate motivation was the most influential factor in the long term.

The teams at our institutions adopted the primary TEP technique as the rehabilitative method of choice; hence, patients were prepared for surgery and for the rehabilitative programme with suitable psychological support. Without neglecting accepted oncologic procedures, the total laryngectomy was altered to accommodate the TEP. It was important to establish a sufficiently ample tracheostoma which

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was not embedded behind the sternum and also to perform a pharyngeal constrictor myotomy.

The pharyngoesophageal hypertonicity or spasm that sometimes prevented patients from acquiring an adequate voice could be overcome either by myotomy or by pharyngeal plexus neurectomy.[19] The only drawback observed, also reported by Mahieu *et al.*,[20] was hypotonic voice in myotomized patients due to excessive hypotonicity of the pharyngeal tract. External manual pressure to the pharynx may improve the quality of speech. Olson and Callaway[21] have suggested not suturing the pharyngeal constrictors across the closure of the pharynx, as an alternative to myotomy or plexus neurectomy. The use of chemical denervation of the pharyngoesophageal segment via transcutaneous injection of botulinum toxin has been reported to be effective for this disorder, without significant complications.[5] However, pharyngoesophageal spasm in the patients studied was adequately relaxed by short-interval, percutaneous lidocaine injection.

Of the group two patients thus treated, results proved favourable in 93.75 per cent of cases with adequate follow up (i.e. three years). The smoother peritracheostomal surface and reduced resistance in the pharyngoesophageal tract enabled the tracheostomal valve to be used more frequently. However, the technique was not entirely trouble free; problems could stem from the endoscopic instruments or from the tracheoesophageal fistula creation and maintenance. According to the literature, complications have an incidence varying from 15 to 25 per cent, and include oesophageal perforation, cervical spine fracture, osteomyelitis of the vertebrae, peristomal and cervical cellulitis, mediastinitis, aspiration, pneumonia, enlarging fistula with salivary leakage, aspiration of the prosthesis, stoma stenosis, oesophageal stenosis, false tract formation, fistula migration, and allergic reaction to the prosthesis.[7,22] Pneumothorax has also been reported as a complication of voice prosthesis use.[23] Granulation tissue can form around the orifice of the fistula in reaction to the foreign body.[6,10,24]

The problems observed in our patients were similar to those described elsewhere in the literature; however, no severe problems were caused by the oesophagoscopic instruments. The onset of problems did not necessarily mean abandoning the prosthesis, and sufficiently motivated patients proved able to overcome most of these problems.

The laryngectomized pharynx presents a number of problems even for the experienced surgeon. It is devoid of recognizable landmarks, and there are multiple folds and culs-de-sac that result from the closure of the pharynx and the healing process. The two most important problems are formation of a stricture at the pharyngeal inlet and formation of a transverse web at the base of the tongue, with a resulting pseudodiverticulum[25] that makes endoscopy of the pharyngoesophagus with rigid instruments difficult. The stenosis should be dilated with a flexible bougie, which will allow easier introduction of the oesophagoscope. If the web produces a pouch, it is best divided by sharp or laser dissection to improve deglutition and visualization of the hypopharynx.[25]

The tracheostoma is affected by the puncture procedure. If it is less than 1.5 cm in greatest diameter, it is difficult to place the prosthesis and maintain an adequate airway. The puncture and the prosthesis will cause a few millimetres of inflammation and oedema, and this will circumferentially narrow the airway. The small stoma should be stented with a silicone tracheotomy tube or should be revised to maintain its lumen after the puncture. The trauma of the puncture, although minimal, will produce local tracheitis, with resultant tracheobronchial secretions. The patient must be alerted to the importance of increased tracheal hygiene in the early postoperative period. Case selection should consider the patient's capacity to care for the trachea before application of the voice restoration procedure.[26]

The puncture procedure does not usually affect swallowing and does not lead to aspiration. If dysphagia is reported, the stenting catheter may be curled in the pharynx, producing obstruction. Aspiration can occur if the puncture is dilated too much during placement of the stenting catheter. This will quickly correct itself, but the trachea must be protected with a tracheotomy tube and inflated balloon. It is important that the stenting catheter is not compressed by the tube against the membranous trachea or a 'decubitus' ulcer will develop, with tracheal necrosis.[7]

The routine use of prophylactic antibiotics has not been a regular practice, except in potentially high-risk patients. This would include diabetic patients, those with severe chronic obstructive lung disease, malnourished individuals and immunosuppressed patients.[27]

Aspiration of the voice prosthesis itself may occur while changing the prosthesis. Patients who develop violent coughing are at risk. A sudden inhalation may drag the prosthesis into the trachea, where it can lodge as deeply as a bronchus. Some patients are capable of effectively coughing the prosthesis out while others require endoscopic retrieval.[28] In this study, we did not observe significant obstruction from prosthesis aspiration, but such patients were dyspnoeic and required emergency intervention. A flexible bronchoscope was employed in these cases.

The advantages of primary voice restoration are direct visualization of the tissues and placement of the puncture through the open pharyngotomy. During the placement of the primary puncture, it is best to avoid dissecting the plane between the oesophagus and the trachea. This may devitalize the trachea and open a potential space for secretions to collect and facilitate subsequent abscess formation. It is important that the stenting catheter does not pull through the mucocutaneous junction of the superior tracheostoma during healing or the puncture will heal superior to the stoma. This complication will make the mechanical connection of the exhaled air stream difficult. Attention must be directed on a daily basis to lateral fixation of the catheter to avoid migration superior to the stoma. It is recommended that the trachea be irrigated with dilute bicarbonate of soda and be continuously misted during the healing interval.[28]

Voice restoration with TEP is not only relatively straightforward but also has the advantage of placing no restrictions on oncologic therapy. Radiotherapy can be used both before and after prosthesis implantation.[29]

In the current study, it was possible for the same patient to develop more than one problem in either category (early or late). This overlapping, in addition to the descriptive nature of the study, prevented statistical comparisons between the two groups.

Conclusion

Although problems occur despite surgeons' best efforts at voice restoration in laryngectomized patients, such problems are manageable when they are recognized early and a methodical treatment plan is formulated. The voice prosthesis and the TEP procedure are today widely used, with high success rates. The problems reviewed in this study are common in head and neck surgery and should be treated in conventional ways. High success rates can be achieved, and large numbers of laryngectomized patients can be rehabilitated to achieve a relatively normal quality of life and social reintegration.

- **This study assessed the morbidity associated with primary and secondary tracheoesophageal puncture for voice restoration following laryngectomy. The study group comprised 43 patients undergoing secondary puncture and 32 undergoing primary puncture**
- **The authors emphasize that, with an intensive, multidisciplinary approach, most adverse events can be treated adequately**

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Address for correspondence:
Dr Mohamed Nasser Elsheikh,
PO Box 34, Tanta, Egypt.

E-mail: mnel_sheikh@hotmail.com

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