An intriguing paradox pertains to patients facing total laryngectomy (TL) for treatment of laryngeal malignancy. Although TL is one of the most notorious and undesirable operation in the armamentarium of the head and neck surgical oncologist, it is among the easiest of the major head and neck procedures from which to recover, with many patients resuming premorbid levels of activity and social functioning. In large part, the surprisingly favourable outcome for the patients of TL may be attributed to a simple, reliable and effective means of voice restoration through the creation of a tracheoesophageal conduit.

Total laryngectomy is a necessary procedure that produces an enduring set of social and functional limitations. Creation of a small passage of air to pass from the trachea to the pharynx facilitates restoration of a near to normal voice, that has become the method of choice for the majority of laryngectomy patients.

**ABSTRACT**

Total laryngectomy is a necessary procedure that produces an enduring set of social and functional limitations. Creation of a small passage of air to pass from the trachea to the pharynx facilitates restoration of a near to normal voice, that has become the method of choice for the majority of laryngectomy patients. The procedure can be performed at the time of laryngectomy or at any point thereafter. The availability of tracheoesophageal prosthesis voice contributes to higher quality of life for patients who require surgery for advanced or recurrent laryngeal cancer.

When voice production using a tracheoesophageal puncture (TEP) is compared with esophageal speech, several interesting observations emerge. Not surprisingly, maximum phonation time, maximum number of syllables that can be produced with one air intake and maximum intensity of sound are greater for TEP speech. In a study comparing 10 esophageal speakers with 10 TEP speakers, the average maximum phonation time with one air intake for esophageal speakers was 1.3 seconds and was 8.2 seconds for the TEP speakers. The TEP speakers were able to utter 25 syllables, compared with only 7 by the esophageal speakers. The dynamic and frequency ranges do not differ between the two methods.

Similarly, in a study that compared speech using an electrolarynx to the speech using TEP produced by the same individual, the rate of speech using the TEP was faster, more intelligible and preferred by listeners who did not know the speaker. This study is anecdotal and some individuals develop excellent diction using an electrolarynx. Still, it is generally accepted that the sound production in the pharyngeal segment is more near to...
normal human voice and therefore is generally preferred by speakers and listeners.

**Technical Aspects of Transesophageal Puncture**

(A) **Timing of insertion of tracheoesophageal prosthesis** – the tracheoesophageal fistula can be created at the time of TL (primary TEP) or at some later date (secondary TEP). Secondary TEP is generally performed after the full healing of the tracheostoma and the completion of postoperative radiation therapy, if such treatment is needed. After irradiation, a period for resolution of local tissue damage induced by that treatment is also needed before the placement of tracheoesophageal prosthesis. Singer originally recommended placement of the prosthesis on postoperative day 2 after secondary TEP.[4] A longer postoperative interval permits a greater degree of maturation of the puncture site, during which time the puncture is maintained by a stent such as a red rubber catheter. Other devices (eg. Provox, Atos Medical) are designed to be placed at the time of TEP.[9] There are advantages and disadvantages to each of these approaches, although the final result does not depend substantially on the issues of timing of puncture or prosthetic insertion.

Primary TEP eliminates the need for a second surgical procedure after TL to create the puncture tract, allows cricopharyngeal myotomy or neurectomy to be performed at the time of puncture and avoids delay in the patient’s development of voice. The disadvantages may be stated as possible limitation of access to the tract if the stoma diameter decreases during healing, especially a concern when postoperative radiation must be delivered. During irradiation, voice production may be inhibited by swelling and pain caused by mucositis. This delay may frustrate the new pharyngeal voice user, causing a loss of motivation to continue with vocal rehabilitation. Some investigators have indicated an increased risk of stoma-related complications associated with primary TEP, including fistula, leakage from the puncture site and local infection with early stomal stenosis.[6] Others have found that primary TEP does not increase the risk of postoperative complications after TL.[7] Finally, some surgeons believe that all patients should have an opportunity to try to develop esophageal speech independent of prosthesis use before puncture.

Prosthetic devices that are placed after a period of stenting permit the use of the TEP tract for enteral feeding through the red rubber catheter stent in the immediate postoperative period and eliminate the need for gastrostomy or nasogastric tube placement. Even when a prosthesis is placed at the time of laryngectomy, voicing must be delayed while the pharyngotomy closure heals. Furthermore, most patients do not find digital occlusion of the stoma to permit voicing comfortable for several weeks postoperatively because of incomplete healing. Hence, the delay in voice use associated with devices placed at a postoperative visit is not much different than that experienced with devices placed at the time of puncture.

(B) **Technique of primary tracheoesophageal puncture** – it is easy to create the tracheoesophageal fistula tract before closure of the pharyngotomy created during removal of the larynx and tumour in TL (Fig. 1). A right-angled forceps can be passed into the esophagus and used to protrude the site for puncture in the party wall.[8] The maturation of the superior rim of the stoma will result in a decrease in the distance from the upper rim to the puncture site, so it is wise to place the puncture lower than visual estimation of the appropriate final position. A distance of 1 cm or slightly more is sufficient. A simple stab incision in a vertical orientation penetrating the tracheal mucosa, submucosa and esophageal mucosa exposes the tines of the clamp. A 14-French red rubber catheter (Fig. 2) can then be passed through the tract and pulled up to the pharyngotomy before turning it downward into the esophagus. When the provox device is placed, a wire is passed up through the puncture into the pharyngotomy and the device is drawn back through the puncture in a retrograde fashion.

The capacity of the esophageal inlet should be assessed either before or after the creation of the puncture. Although, either too tight or too loose a pharynx can cause problems with voice production, the former problem is more commonly encountered and can be more directly addressed. If the inlet does not admit the index finger of the surgeon with only minimal snugness, a myotomy or neurectomy (avulsion of end fibers of recurrent laryngeal nerve from cricopharyngeus muscle) should be contemplated. A cricopharyngeal myotomy through the posterior muscular fibers, is the usually preferred procedure. This procedure can be easily accomplished by rotating the esophagus on the inserted finger to expose the posterior aspect of the outer surface. A no. 15 blade or needle cautery is then used lightly to release muscle fibers in a vertical orientation. The resulting laxity of the inlet can be judged immediately by a sense of loosening around the finger.

A tight closure above the esophageal inlet caused by partial resection of hypopharyngeal mucosa to ensure adequate tumour margins should be avoided. Flap reconstruction using platysma, radial forearm, pectoralis or other appropriate tissue helps provide a neopharynx that is adequate for voice production and swallowing.

(C) **Technique of Secondary Tracheoesophageal Puncture** – Singer and Blom (1981) described an endoscopic approach to the TEP site to create a puncture tract safely at some time after full healing of the pharyngotomy created during a TL.[9] A rigid esophagoscope was inserted to protect the posterior wall of the esophagus and the underlying prevertebral space from puncture and infection. The puncture was placed 3 to 5 mm below the mucocutaneous junction of the upper rim of the stoma. The poor visibility with a rigid
esophagoscope compounded the awkwardness of these early attempts at secondary TEP in which a wire or filiform dilator was pulled up and out of the mouth, followed by dilators and finally by the stent. The stent then had to be fixed in place, either completing a circuit from tracheostoma to oropharynx to nasopharynx and out of the nares or by turning the catheter blindly back into the esophagus.

Numerous modifications of the technique for secondary TEP have been proposed and published. Wayne et al prefer to approach the esophageal puncture site with a flexible fiberoptic esophagoscope. The ideal puncture site is just below the esophageal inlet, so the insufflating function of the esophagoscope successfully opens the lumen. Probing the posterior wall of the trachea with a pointed instrument confirms the entry site before placement of a puncturing 16-gauge needle. It is useful to place a gentle curve in the needle to direct the tract slightly upward. The puncture is performed by short jabbing motions under direct vision through the esophagoscope to avoid injury of the posterior esophageal wall. A wire can be passed through the needle, the needle removed and the tract dilated using serial dilators and a Seldinger technique. A kit containing a tear-away sheath that fits over an appropriate sized dilator is commercially available (Russell Percutaneous Gastrostomy Kit – Cook Inc. Bloomington, IN). Dilator and wire are removed, a 14-French red rubber catheter is placed through the sheath and the sheath is torn back, leaving the catheter in place directed downward into the esophagus. This technique is easy to perform and permits completion of secondary puncture in about 5 minutes.

When a Provox device is used, the technique of secondary puncture requires passage of a wire or cord from the puncture site into the mouth to pull the prosthesis into position in a retrograde fashion. Introducing a device that folds the inner flange and permits direct placement into the puncture site of the stoma facilitates subsequent replacement of the prosthesis.

A technique for creating a secondary TEP in the clinic setting under local anaesthesia has been described. The puncture is accomplished by placing a needle through the party wall and into a bougie dilator that has been passed into the pharynx. The dilator is then removed, a wire is passed under direct vision using a fiberoptic laryngoscope and dilation is followed by prosthesis placement.

The proper placement of the prosthesis is confirmed by easy and clear voice production. When the positioning is in question, it can be checked with a 2 mm rigid zero degree telescope. The telescope can be passed through the flutter valve at the esophageal end of the prosthesis cylinder. As the telescope opens the flap, smooth, moist, pale, pink esophageal mucosa and saliva should be clearly visible. If, instead, the surrounding tissue is red and dull, the prosthesis is not long enough and is lodged within the tract of the puncture site.

Several physical factors can make prosthesis replacement challenging. Some patients are very sensitive and any manipulation of the stomal region causes coughing. Coughing may be associated with copious mucus. The angle of the tract, narrowness of the stoma and granulation around the introitus, all may contribute to difficulties. Temporary placement of a tapered dilator and stent during the changing procedure can help prevent salivary leakage and aspiration of pharyngeal secretions and maintain and dilate the tract while the replacement device is prepared for introduction.

LEGENDS FOR FIGURES
Fig. 1: Esophagoscope placed with distal flange facing anteriorly. The tip is situated just below the upper lip of tracheostoma. A 14 gauge French intracath needle is punctured through the party wall and threaded into the esophagoscope lumen.
Fig. 2: (A) Red rubber catheter left in situ secured by a heavy silk ligature. (B) Singer-Blom prosthesis. (C) Prosthesis in place.

(D) Fitting and maintaining a prosthesis – the thickness of the wall between trachea and esophagus tends to decrease during the early postoperative period. For this reason, the first prosthesis placed may be too long by the time of follow-up visits. A sizing device provided by the prosthetic manufacturer is used at the initial fitting and subsequently as needed to determine the size of prosthesis necessary for a snug but not overly tight fit.
CONFLICT OF INTERESTS
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