Objective: To compare and contrast functional speech outcomes of patients having undergone total laryngectomy and pharyngolaryngectomy who use tracheoesophageal speech as their primary mode of communication.

Design: Group comparison design.

Setting: Adult acute tertiary care hospital.

Patients: Thirty patients who underwent total laryngectomy and 13 who underwent pharyngolaryngectomy with free jejunal interposition reconstruction. All patients used tracheoesophageal speech.

Intervention: Group comparisons across measures of speech intelligibility, voice quality, tracheoesophageal speech use, voice satisfaction and levels of perceived voice disability, handicap, and well-being/distress.

Main Outcome Measure: The existence of any significant differences between the 2 groups on measures of intelligibility, voice quality, tracheoesophageal speech use, and voice satisfaction and levels of voice disability, handicap, and well-being/distress.

Results: Statistical comparisons confirmed reduced functional intelligibility ($P < .05$), reduced vocal quality ($P < .01$), and higher levels of disability ($P < .05$) in the pharyngolaryngectomy group. However, no significant difference was observed between the proportion of patients classified as “successful” tracheoesophageal speech users in either group. Low levels of handicap and high levels of patient well-being were recorded in both groups.

Conclusion: Despite the perceptual differences in voice quality and intelligibility observed between the 2 groups, tracheoesophageal speech that is functional, effective, and perceived by the patients as satisfactory can be achieved after total laryngectomy and pharyngolaryngectomy with free jejunal interposition reconstruction.


TOTAL LARYNGECTOMY (LAR) and the more extensive pharyngolaryngectomy (PLAR) are performed to excise cancers of the larynx and hypopharynx. Removal of the cancer, and consequently the laryngeal and pharyngeal tissues, has a significant impact on speech, swallowing, and respiration.1 The effect of these types of surgery on tracheoesophageal speech production and perceived levels of disability, handicap, and well-being is the specific focus of this investigation.

Tracheoesophageal speech has become a reliable, well-established technique of voice restoration after LAR.2 Its principal goal is the production of intelligible speech and fluent, effortless voice.3 To achieve tracheoesophageal speech, a puncture is created in the tracheoesophageal wall and fitted with a unidirectional prosthesis that allows for the diversion of pulmonary air into the esophagus.1 This enables vibration to occur either at the pharyngoesophageal segment (LAR)4 or predominantly at the lower anastomotic border of the jejunal segment (PLAR).5 producing sound. After LAR, a high level of successful communication has been achieved with tracheoesophageal speech.2 Most patients have achieved functional speech with good quality and high intelligibility1,2,6 and a high degree of social acceptability.2 In addition, results of recent studies indicate that LAR patients have high levels of satisfaction with their tracheoesophageal speech,7,8 with a high degree of successfulness of use.8 Tracheoesophageal speech has also been recommended for patients who undergo PLAR. Because of the extended resections and pharyngeal reconstructions required after PLAR, this patient group has a low probability of acquiring functional esophageal speech.9 The advent of tracheoesophageal speech has increased the opportunities for these patients to develop a successful form of communication after PLAR.9 In contrast to the re-
PATIENTS AND METHODS

PATIENTS

We studied 30 patients who had undergone LAR (27 men and 3 women; mean age, 63.2 [7.9] years) and 13 patients who had undergone PLAR and reconstruction with free jejunal interposition (10 men and 3 women; mean age, 64.8 [7.6] years). Patients had received either primary (23 patients in the LAR group and 7 in the PLAR group) or secondary (7 patients in the LAR group and 6 in the PLAR group) surgical voice restoration, and assessment was performed at least 6 months after voice restoration (mean duration, 28.7 [26.2] months; range, 8.0-126.0 months). All patients had a voice prosthesis in situ, which had been deemed by their speech pathologist to facilitate optimal voice at the time of assessment. Nineteen of 30 LAR patients and 11 of 13 PLAR patients underwent postoperative irradiation. Assessment was performed at least 6 months after radiotherapy.

PROCEDURE

All patients were assessed using perceptual ratings of speech intelligibility and acceptability and using questionnaires to investigate speech outcomes. On average, 20 minutes was required to complete all investigations. The study received ethical clearance from the research ethics committees of the Royal Brisbane Hospital, Princess Alexandra Hospital, and the University of Queensland, Brisbane, Queensland. In addition, written consent was obtained from all patients before participation in the study.

RESULTS

Because of uneven group sizes and the small number of patients in the PLAR group, Mann-Whitney U tests were used to determine if any significant differences occurred between the 2 groups on all variables. Where nominal data were collected, the proportion test was used for group comparison.

PERCEPTUAL SPEECH MEASURES

Perceptual analysis of a standard passage, “The Grandfather Passage,” was completed using an adapted version of an existing perceptual rating scale. This 5-point rating scale assesses patients’ voices over the 4 dimensions of effort level, external noise, pleasantness, and naturalness. In addition to these ratings, a fifth dimension, overall intelligibility in connected speech, was included. The Multiple Word Intelligibility Test and the Assessment of Intelligibility of Dysarthric Speech were used to provide a measure of intelligibility in single words and sentences, respectively.

OUTCOME MEASURES

Patient outcomes were investigated using the Harrison-Robillard Shultz TEP (Tracheoesophageal Puncture) Rating Scale, which aims to give an indication of the overall level of success of each patient’s tracheoesophageal “speech use,” “voicing production,” and “self-care”; the Therapy Outcome Measures Laryngectomy Scale, developed to give the clinician or researcher an indication of the degree of voice impairment, handicap, and well-being/distress experienced by the laryngectomy patient; and Part A of the Patient Satisfaction Questionnaire, a series of 13 multiple-choice questions that evaluate patients’ perceptions of, and satisfaction with, tracheoesophageal speech. A rating of 1 on this scale indicated a highly negative result (eg, very dissatisfied), and a rating of 5 indicated a highly positive result (eg, very satisfied). Question 6 from the questionnaire was excluded from the statistical comparisons because more than 90% of patients in the LAR and PLAR groups had not been taught esophageal speech.

Data are presented as mean (SD).

Voice quality in the LAR and PLAR groups was significantly different. Statistical analysis revealed that the PLAR group required significantly greater effort to produce speech (PLAR: 3.31 [0.95]; LAR: 2.06 [0.16]) (U = 3.58; P < .001), were perceived to exhibit significantly reduced pleasantness (PLAR: 3.23 [0.93]; LAR: 2.29 [0.90]) (U = 3.24; P = .001) and naturalness (PLAR: 3.15 [0.90]; LAR: 2.42 [0.99]) (U = 3.12; P = .002), and were perceived to have significantly increased extraneous noise (PLAR: 2.46 [0.66]; LAR: 1.81 [0.70]) (U = 2.84; P = .01) in their speech than did the LAR group.

No significant difference was observed between the LAR (84.5% [5.0%]) and PLAR (82.6% [3.0%]) groups for single-word intelligibility. In contrast, statistical analysis of the Assessment of Intelligibility of Dysarthric Speech data revealed a significant difference between the 2 groups for mean percentage of intelligibility at the sentence level (PLAR: 87.3 [13.5]; LAR: 94.1 [7.0]), with the PLAR group significantly less intelligible than their LAR counterparts (U = 2.26; P = .02). Overall intelligibility on the reading task was also significantly reduced in the PLAR group vs the LAR group (PLAR: 1.77 [0.73]; LAR: 1.23 [0.43]) (U = 2.76; P = .006).
OUTCOME MEASURES

Twenty-nine LAR patients (97%) and 10 PLAR patients (77%) were judged to be successful tracheoesophageal speakers per the TEP rating scale. Statistical comparisons of proportions, however, revealed that the proportion of successful tracheoesophageal speakers in both groups was not significantly different (U = 1.47; P = .14).

Comparisons between group means on the disability, handicap, and well-being/distress scales of the Therapy Outcome Measures Laryngectomy Scale revealed a significant difference between the PLAR (3.38 [0.87]) and LAR (4.47 [0.57]) groups on the disability scale only (U = 3.67; P < .001). Proportion tests revealed that the PLAR group had a significantly higher proportion of patients rated at disability level 3 and a significantly lower proportion rated at disability level 5 than the LAR group (Table 1). This result indicated higher levels of disability in the PLAR group. No significant difference between group means was observed for the handicap rating (PLAR: 4.38 [0.77]; LAR: 4.5 [0.69]) or the well-being/distress rating (PLAR: 4.15 [0.8]; LAR: 4.43 [0.57]).

Statistical comparisons between the mean group ratings on each of the questions from the Patient Satisfaction Questionnaire revealed only one significant difference between the groups (U = 3.07; P < .01). The results of question 11 (telephone use) (Table 2) revealed that PLAR patients reported significantly reduced levels of comfort when speaking on the telephone. Responses to all other questions were not significantly different between the groups (Table 2).

Our results confirm that the voice quality achieved using tracheoesophageal speech following PLAR is significantly less pleasant, with a reduced level of speech intelligibility, than the tracheoesophageal voice quality and levels of speech intelligibility achieved by most LAR patients. These reductions in speech intelligibility and voice quality were also reflected in the higher disability ratings recorded by PLAR patients. However, in contrast to these negative findings, results of the outcome measures indicated that although the voice quality and speech

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**Table 1. Comparison of the Distribution of Total Laryngectomy and Pharyngolaryngectomy Patients Across the Disability Ratings From the Therapy Outcome Measures Laryngectomy Scale**

<table>
<thead>
<tr>
<th>Disability Rating</th>
<th>Patients, No. (%)</th>
<th>Pharyngolaryngectomy Group (n = 13)</th>
<th>Total Laryngectomy Group (n = 30)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rating 2</td>
<td></td>
<td>2 (15)</td>
<td>0</td>
<td>.16</td>
</tr>
<tr>
<td>Pseudo voice production is effective with attention of listener in modified environments; requires considerable effort</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rating 3</td>
<td></td>
<td>5 (38)</td>
<td>1 (3)</td>
<td>.01*</td>
</tr>
<tr>
<td>Pseudo voice is effective on certain occasions; requires some personal effort all the time</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rating 4</td>
<td></td>
<td>5 (38)</td>
<td>14 (47)</td>
<td>.87</td>
</tr>
<tr>
<td>Pseudo voice is effective on most occasions; slightly effortful; able to use the telephone</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rating 5</td>
<td></td>
<td>1 (8)</td>
<td>15 (50)</td>
<td>.02*</td>
</tr>
<tr>
<td>Pseudo voice is effective in all situations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant at P < .05.

**Table 2. Comparison Between Group Means for Each of the 12 Questions From the Patient Satisfaction Questionnaire**

<table>
<thead>
<tr>
<th>Question†</th>
<th>Total Laryngectomy Group</th>
<th>Pharyngolaryngectomy Group</th>
<th>U</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How did the laryngectomy surgery affect the way you think of yourself?</td>
<td>4.60 (0.72)</td>
<td>4.38 (0.77)</td>
<td>0.06</td>
<td>.29</td>
</tr>
<tr>
<td>2. Prior to the surgery, how talkative were you?</td>
<td>4.32 (0.88)</td>
<td>4.00 (1.00)</td>
<td>1.02</td>
<td>.31</td>
</tr>
<tr>
<td>3. How talkative are you now with your TE voice?</td>
<td>3.93 (1.11)</td>
<td>3.62 (0.96)</td>
<td>1.09</td>
<td>.28</td>
</tr>
<tr>
<td>4. How self-conscious are you having to occlude the stoma?</td>
<td>4.37 (1.16)</td>
<td>4.23 (1.01)</td>
<td>0.85</td>
<td>.40</td>
</tr>
<tr>
<td>5. How do you rate the quality of your TE speech compared with AL speech?</td>
<td>4.70 (0.53)</td>
<td>4.31 (1.18)</td>
<td>0.61</td>
<td>.54</td>
</tr>
<tr>
<td>6. How comfortable are you using TE speech with family?</td>
<td>4.87 (0.35)</td>
<td>4.54 (0.97)</td>
<td>0.54</td>
<td>.59</td>
</tr>
<tr>
<td>7. How comfortable are you using TE speech with strangers?</td>
<td>4.47 (0.90)</td>
<td>3.85 (1.21)</td>
<td>1.85</td>
<td>.06</td>
</tr>
<tr>
<td>8. How comfortable are you using TE speech in noisy environments?</td>
<td>3.70 (1.12)</td>
<td>2.92 (1.26)</td>
<td>1.93</td>
<td>.05</td>
</tr>
<tr>
<td>9. How comfortable are you using TE speech in quiet environments?</td>
<td>4.67 (0.48)</td>
<td>4.54 (0.88)</td>
<td>0.02</td>
<td>.99</td>
</tr>
<tr>
<td>10. How comfortable are you using TE speech on the telephone?</td>
<td>4.53 (0.73)</td>
<td>3.38 (1.19)</td>
<td>3.07</td>
<td>.002†</td>
</tr>
<tr>
<td>11. How satisfied are you with your TE speech?</td>
<td>4.40 (0.72)</td>
<td>3.92 (0.86)</td>
<td>1.85</td>
<td>.06</td>
</tr>
</tbody>
</table>

* TE indicates tracheoesophageal; AL, alaryngeal.
† Question 6 was not included in the present study.
‡Significant at P < .01.
Intelligibility of PLAR patients was reduced overall, the PLAR group was satisfied with their speech rehabilitation. In addition, their degree of handicap and well-being/distress were low and comparable to those of LAR patients.

PERCEPTUAL SPEECH MEASURES

Significant differences in vocal quality were found between the LAR and PLAR groups in the present investigation. These differences were found across all variables, with the PLAR group exhibiting increased extraneous noise, requiring increased effort levels to produce speech, and exhibiting significantly reduced scores for pleasantness and naturalness of speech. The reduced vocal quality observed in the present group of PLAR patients is consistent with previous findings of Wenig et al., who reported “coarse” voicing in their group of 5 PLAR patients, 4 of whom had undergone reconstruction with free jejunal interposition. Wilson et al. reported similar findings of “gravelly” voicing in their group of 9 PLAR patients who had undergone jejunal interposition reconstruction. In addition, the findings of reduced pleasantness and naturalness in the present investigation compare favorably with the lower social acceptability scores reported by Mendelsohn et al. in their group of 7 PLAR patients who underwent reconstruction with jejunal interposition. On the basis of the present data and previously reported literature, there is evidence to support that the jejunal segment produces an altered vibratory tone in PLAR patients that is distinctive from the vibratory quality produced from the muscular vibratory segments in LAR patients.

Overall, the mean percentage of intelligibility ratings of all patients investigated in the present study was high, indicating that most patients from both groups function with only mild reductions in their sentence-level intelligibility. In addition to these findings, the overall perceptual rating of intelligibility in connected speech indicated that the level of intelligibility in both groups was mild to moderately affected. Direct comparisons between the intelligibility levels of both groups, however, revealed that 2 of the 3 intelligibility measures were significantly different between the 2 groups. Assessment of single-word intelligibility revealed no significant difference between the group means, although a significant difference was found at the sentence level and in the overall rating of intelligibility, indicating reduced levels of functional intelligibility in PLAR patients.

The sentence intelligibility of 87.3% recorded in the present investigation for PLAR patients was significantly lower than the LAR group mean score of 94.1% intelligibility. Previous documentation of sentence-level intelligibility data is limited for LAR and PLAR patients, although Bridges reported a sentence intelligibility level of 97.4% for LAR patients using the Assessment of Intelligibility of Dysarthric Speech in the only published study to date. These data compare favorably with the 94.1% intelligibility recorded by LAR patients in the present study using the same assessment tool. To our knowledge, no study has quoted a sentence intelligibility figure for PLAR patients. Our findings of reduced intelligibility in sentences and via a rating scale are consistent with the findings of Mendelsohn et al, who reported that the speech of PLAR patients is more difficult to understand than that of LAR patients.

The lack of significant difference between the 2 groups at the single-word level in contrast to the differences observed in connected speech could be explained by the impact of reduced voice quality in the PLAR group. Perceptual ratings of speech intelligibility are affected by a number of extraneous factors (eg, effort level, sound intensity, and vocal quality) in addition to articulatory precision. In single-word production, it is much easier for the patient to clearly produce the target because it requires only a short vibratory burst. Conversely, in connected speech, the patient must be able to coordinate the breath stream while maintaining a continuous vibratory signal, therefore preserving the syntactic structure and semantic units in the utterance, which facilitate listener comprehension. In the present study it has been identified that PLAR patients are perceived as having large amounts of extraneous noise in their speech and produce the utterances with a high degree of effort. It is therefore possible that their reduced ability to produce a clear, effortless vibratory signal could be a significant factor influencing intelligibility in connected speech.

OUTCOME MEASURES

The results of the present investigation indicate similar levels of successful tracheoesophageal speech for LAR and PLAR patients. Twenty-nine (97%) of 30 LAR patients were classified as “successful” tracheoesophageal speakers using this scale compared with 10 (77%) of 13 PLAR patients. These results are consistent with the high-level successful tracheoesophageal speech acquisition recorded by Silverman and Black. An overall success rate of 81% for tracheoesophageal speech acquisition was recorded in 2 groups of LAR patients (divided by timing of radiation therapy). Further success rates of 64% and 62% have also been reported in LAR patients using different measurement scales.

To our knowledge, no previous research has investigated the degree of successful tracheoesophageal speech acquisition after PLAR; therefore, the high incidence of successful tracheoesophageal speech in this patient group is encouraging. For subgroups of PLAR and LAR patients who did not achieve successful voicing, examination of their raw data scores revealed reduced scores relating to voice quality in the voicing production section of the scale and ultimately led to their being classed as “unsuccessful” tracheoesophageal speakers.

In addition to high levels of successful speech acquisition, both patient groups reported similar levels of satisfaction with their tracheoesophageal speech. All patients in the LAR and PLAR groups rated themselves as at least “accepting” of their tracheoesophageal speech, with most patients in both groups feeling either “satisfied” or “very satisfied” with their tracheoesophageal speech as a method of communication. Eighty-seven percent (26/30) of the LAR patients rated themselves as either “satisfied” or “highly satisfied” with their tracheoesophageal speech, as did 62% (8/13) of the PLAR patients.
These results are comparable to those reported by Silverman and Black, who found that 89% of LAR patients rated their tracheoesophageal speech to be a “highly favorable” method of communication.

Although both groups were satisfied with their tracheoesophageal speech across a wide range of situations, a significant difference was found between their satisfaction levels for telephone use. The PLAR group exhibited significantly reduced levels of comfort while speaking on the telephone. It would be assumed that this difference would relate to the findings of reduced intelligibility and voice quality in this group. Mendelsohn et al. reported that PLAR patients in their study exhibited reduced levels of intelligibility when speaking on the telephone.

Pharyngolaryngectomy patients’ reduced vocal quality, reduced sentence intelligibility, and reduced comfort levels while speaking on the telephone would all have contributed to the finding of increased disability in the PLAR group. On the Therapy Outcome Measures Laryngectomy Scale, LAR group responses were found to concentrate in the upper end of the scale, indicating limited levels of disability experienced. In contrast, PLAR patients’ responses were more evenly spaced on the scale, and a significantly greater proportion of PLAR patients exhibited scores in the lower portions of the scale. These results indicated an acknowledgment by PLAR patients of a reduction in the overall effectiveness of their tracheoesophageal speech.

Although PLAR patients in this investigation identified their increased level of disability and reduced vocal quality, they seem to be well adjusted to, and accepting of, this level of disability. Responses of PLAR patients in the handicap and well-being sections of the Therapy Outcome Measures Laryngectomy Scale reflected this adjustment, as no significant difference was found between the 2 groups on either section. Most respondents in both groups indicated that they were at least mostly confident in their social roles, with only occasional difficulty, and that they were participating in all appropriate decision making in their social environment. With respect to well-being, the majority of respondents indicated that they felt, at most, only mild or occasional feelings of upset, frustration, anger, distress, embarrassment, concern, and withdrawal. This finding is consistent with the high proportion of patients who rated themselves as satisfied or highly satisfied with their tracheoesophageal speech.

### CONCLUSIONS

The results of the present investigation confirm that the quality of voice achieved using tracheoesophageal speech after PLAR surgery with free jejunal interposition reconstruction is significantly less intelligible and less pleasant than the voice quality achieved by most LAR patients. However, although these differences in speech intelligibility and voice quality exist, our measures show that, overall, both groups achieved comparable proportions of patients rated as successful tracheoesophageal speech users and that PLAR patients were equally satisfied and accepting of their speech, despite the reduced voice quality. Our present group of PLAR patients had similar low levels of handicap and high levels of well-being as their LAR counterparts and viewed surgical tracheoesophageal voice restoration as a highly satisfactory form of vocal rehabilitation. Previous research has identified quality differences in the tracheoesophageal speech of patients after PLAR, yet none has investigated the impact of these differences on patients’ overall level of acceptance and functional voice outcome. The present research highlights that patient acceptance and satisfaction with tracheoesophageal voice is equally high in PLAR patients as in LAR patients, despite the quality differences. The present data, therefore, further validate the use of tracheoesophageal speech as a functional method of alaryngeal communication after LAR and PLAR.

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