

## Clinical Record

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# Immediate selective laryngeal reinnervation in vagal paraganglioma patients

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## Abstract

**Objective.** This prospective case series aimed to present the outcomes of immediate selective laryngeal reinnervation.

**Methods.** Two middle-aged women with vagal paraganglioma undergoing an excision operation underwent immediate selective laryngeal reinnervation using the phrenic nerve and ansa cervicalis as the donor nerve. Multidimensional outcome measures were employed pre-operatively, and at 1, 6 and 12 months post-operatively.

**Results.** The voice handicap index-10 score improved from 23 (patient 1) and 18 (patient 2) at 1 month post-operation, to 5 (patient 1) and 1 (patient 2) at 12 months. The Eating Assessment Tool 10 score improved from 20 (patient 1) and 24 (patient 2) at 1 month post-operation, to 3 (patient 1) and 1 (patient 2) at 12 months. There was slight vocal fold abduction observed in patient one and no obvious abduction in patient two.

**Conclusion.** Selective reinnervation is safe to perform following vagal paraganglioma excision conducted on the same side. Voice and swallowing improvements were demonstrated, but no significant vocal fold abduction was achieved.

## Introduction

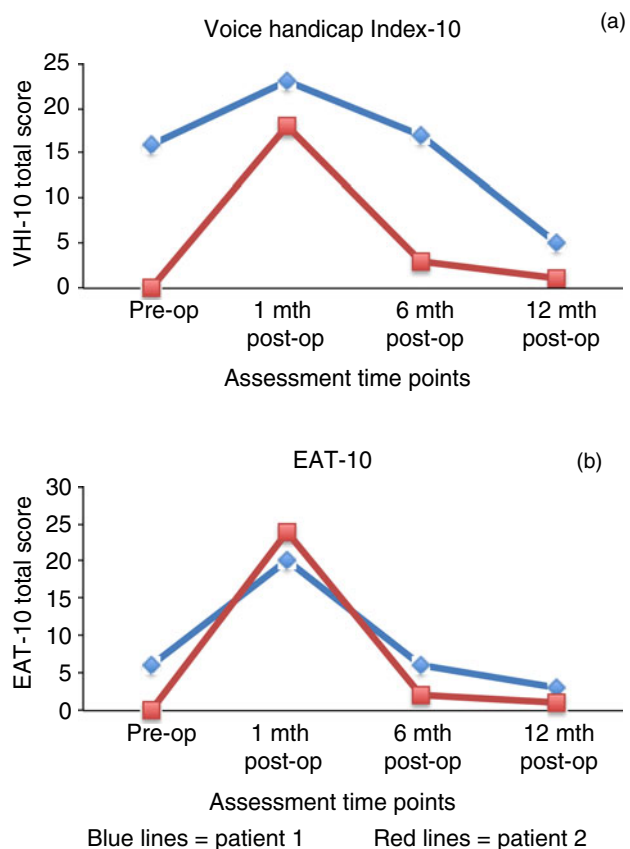
Patients with a cervical vagal tumour commonly present with a neck mass; the majority of patients are asymptomatic as tumour growth is gradual. The definitive treatment for this condition is surgery, which is associated with post-operative unilateral vagal paralysis.<sup>1</sup> Unilateral vagal paralysis patients suffer dysphonia, dysphagia and aspiration. Additional operative complications of glossopharyngeal and hypoglossal nerve paralysis worsen the swallowing problems.<sup>2,3</sup>

Multiple paraganglioma is common, especially in patients with a family history of the condition.<sup>4</sup> Netterville *et al.* reported that 37 per cent of vagal paragangliomas were bilateral.<sup>5</sup> Multicentricity of vagal paragangliomas is a significant factor to consider when deciding on the treatment.<sup>1</sup> Urquhart *et al.* reported that 3 of 19 patients with paraganglioma were subjected to irradiation therapy rather than surgery because of multicentricity.<sup>4</sup> This was to avoid the incapacitating morbidity of bilateral vocal fold paralysis, which might result in a tracheostomy.

Dysphonia, dysphagia and aspiration caused by unilateral vagal paralysis following vagal paraganglioma excision are significant issues that require rehabilitation. Surgical interventions to improve voice and swallowing in such cases include thyroplasty, arytenoid adduction, injection laryngoplasty and laryngeal reinnervation.<sup>3,4,6–8</sup> These studies have shown the usefulness of the surgical interventions in rehabilitating the voice and improving swallowing issues. However, the results were limited by the retrospectivity of the studies, inherent biases, and the lack of details regarding the effects of voice and swallowing treatment outcome monitoring.

Surgical interventions are ideally performed at the same sitting to minimise post-operative morbidity. Laryngeal reinnervation may be a good option as the operation is preferably conducted under general anaesthesia and it does not require fine-tuning of the voice. Surgical reinnervation that aims to re-establish the tone and bulk of the denervated muscle may be better than other surgical techniques. Woodson, in 2007, showed that spontaneous regeneration did not occur following vagus transection in cats, possibly because of the long course of the nerve to the recurrent laryngeal nerve (RLN), and only a small proportion of the axons go to the RLN.<sup>9</sup> Furthermore, re-establishment of vocal fold mobility may be possible by performing selective reinnervation, which may save patients from irradiation therapy or tracheostomy should the tumour subsequently grow on the opposite side of the neck.

A prospective study with standardised outcome measures is necessary to demonstrate the effect of selective reinnervation in patients with unilateral vagal paralysis following surgery on the same side as the vagal paraganglioma. This prospective study aimed to present the outcomes of selective laryngeal reinnervation in terms of improving voice, alleviating aspiration and re-establishing vocal fold mobility in patients with unilateral vagal paralysis following vagal nerve tumour excision.



**Fig. 1.** Graphs showing improvements of (a) voice and (b) swallowing in patients one and two, as measured by the Voice Handicap Index 10 (VHI-10) and Eating Assessment Tool 10 (EAT-10) respectively. Pre-op = pre-operation; mth = month(s); post-op = post-operation

**Materials and methods**

**Patient selection**

Two female patients diagnosed with left cervical vagal paraganglioma undergoing an excision operation were included

in the study. Patient one (40 years old) had left vocal fold paralysis at presentation to the clinic, whereas patient two (52 years old) had normal vocal folds at presentation. Neither patient had any other medical problems.

**Outcome measures**

The patients were assessed pre- and post-operatively, using multidimensional measures, to examine voice improvement, and to assess the effect of reinnervation on the thyroarytenoid muscles and swallowing. The measures included: (1) the voice handicap index 10;<sup>10</sup> (2) voice perceptual evaluation (with the grade, roughness, breathiness, asthenia, strain (‘GRBAS’) scale); (3) acoustic analysis using OperaVOX (jitter, shimmer, noise-to-harmonic ratio);<sup>11</sup> (4) video-laryngostroboscopy (mucosal asymmetry, duration of closure, vocal fold bowing, vocal fold abduction); and (5) a swallowing questionnaire (10-item Eating Assessment Tool; ‘EAT-10’).

The outcome measures were employed at baseline, and at 1, 6 and 12 months post-operatively.

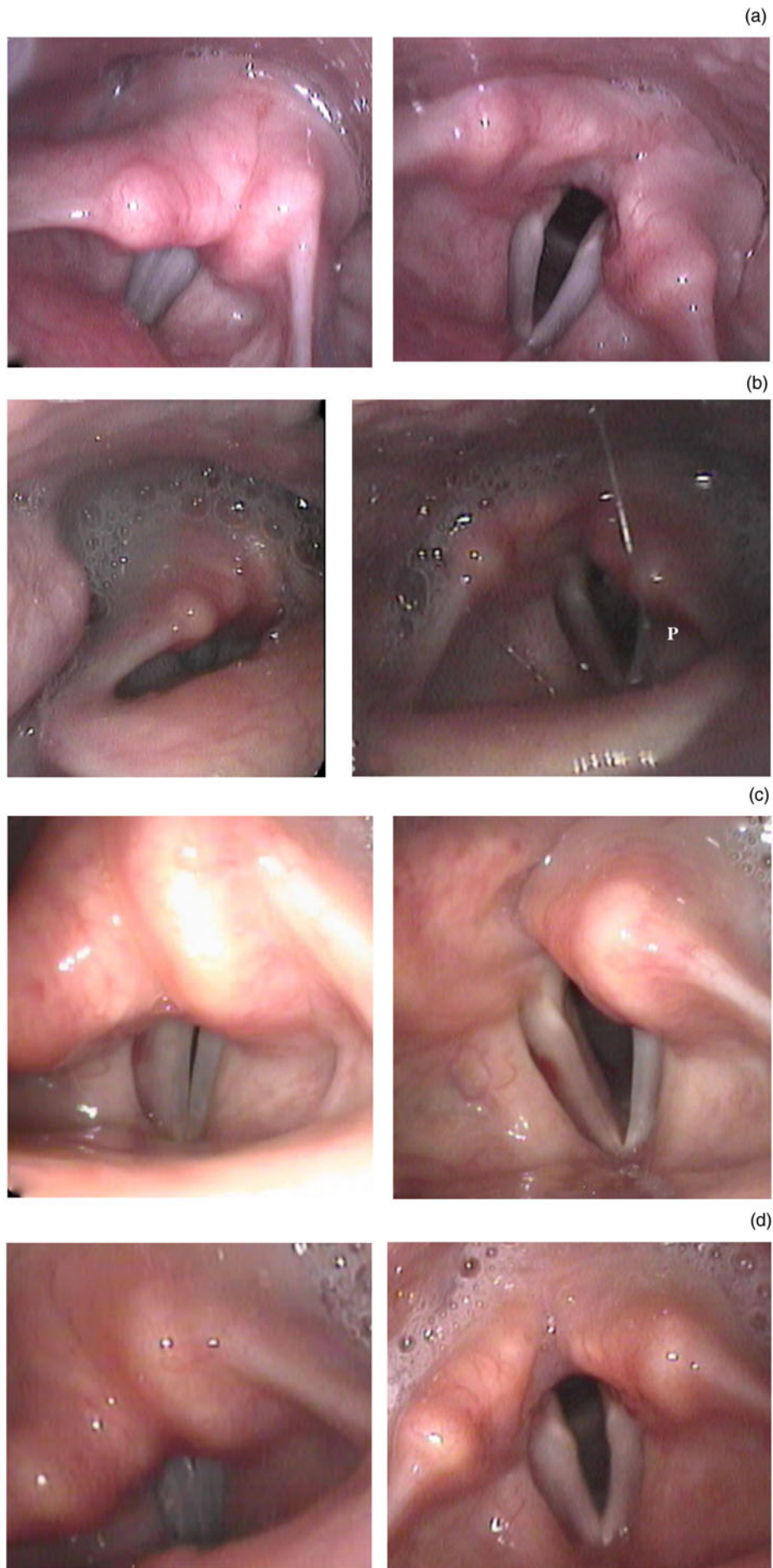
**Selective reinnervation surgical technique**

Selective laryngeal reinnervation was conducted following vagal nerve tumour surgery, either in the same sitting or five weeks following the excision operation. The thyropharyngeus muscle overlying the lateral border of thyroid cartilage lamina was divided for the purpose of intra-laryngeal RLN dissection. The main trunk of the RLN was identified behind the cricothyroid joint. The abductor and adductor branches of the RLN were then identified. The phrenic nerve was normally found deep to the transverse cervical artery, overlying the anterior scalenus muscle. A split phrenic nerve technique was used to reinnervate the posterior cricoarytenoid muscle.<sup>12</sup> The greater auricular nerve was used as a cable graft to bridge the phrenic nerve and the distal stump of the RLN before it branched into the abductor branch. The adductor branch of the RLN was anastomosed to the ipsilateral ansa cervicalis

**Table 1.** Summary of voice and swallowing assessments, and acoustic analysis

Parameter	Patient 1 assessment time point				Patient 2 assessment time point			
	Pre-op	1 mth post-op	6 mth post-op	12 mth post-op	Pre-op	1 mth post-op	6 mth post-op	12 mth post-op
VHI-10 score	16	23	17	5	0	18	3	1
Overall dysphonia grade	2	1	2	1	0	1	0	0
Roughness score	2	1	1	0	0	1	0	0
Breathiness score	1	1	2	1	0	1	0	0
Jitter (%)	1.46	1.44	2.41	1.4	0.53	1.09	0.86	0.54
Shimmer (%)	2.71	1.28	1.9	1.67	1.76	3.54	2	2.36
Noise-to-harmonic ratio	0.1	0.08	0.1	0.07	0.12	0.11	0.08	0.09
Maximum phonation time (seconds)	15	10	9	10	15	10	9	9
Mucosal asymmetry score	0	0	0	0	0	2	0	0
Duration of closure score	0	0	1	0	0	1	0	0
Vocal fold bowing (n)	0	0	1	0	0	1	0	0
EAT-10 score	6	20	6	3	0	24	2	1

Mucosal asymmetry and duration of closure were scored according to a stroboscopy research instrument developed and validated by Rosen *et al.*<sup>14</sup> Pre-op = pre-operation; mth = month(s); post-op = post-operation; VHI-10 = voice handicap index 10; EAT-10 = Eating Assessment Tool 10



**Fig. 2.** Endoscopic images of patient 1 during phonation (left column) and breathing (right column) at: (a) before, and (b) 1, (c) 6 and (d) 12 months after selective reinnervation. Paralyzed vocal fold is marked with 'P'.



**Fig. 3.** Endoscopic images of patient 2 during phonation (left column) and breathing (right column) at: (a) 1, (b) 6 and (c) 12 months after selective reinnervation. Her normal vocal folds before the operation are not shown here. Paralysed vocal fold is marked with 'P'.

nerve.<sup>13</sup> The left vocal fold was injected with porcine collagen (Permacol; Tissue Science Laboratories, Aldershot, UK) to temporarily help the voice while waiting for the reinnervation to occur.

## Results

The voice handicap index 10 scores improved from 23 (patient 1) and 18 (patient 2) at 1 month post-operation, to 5 (patient 1)

and 1 (patient 2) at 12 months. The Eating Assessment Tool score improved from 20 (patient 1) and 24 (patient 2) at 1 month post-operation, to 3 (patient 1) and 1 (patient 2) at 12 months (Figure 1). There was slight vocal fold abduction observed in patient one and no obvious abduction in patient two.

Results of the patients' vocal and swallowing assessments before the operation, and at 1, 6 and 12 months after the operation are summarised in Table 1.<sup>14</sup>

Endoscopic images of the patients at different time points are depicted in Figures 2 and 3. Endoscopic examination showed: no bowing of the paralysed vocal fold, closure of the phonatory gap and improvement of muscle tension dysphonia features at 12 months after the operation compared to baseline.

## Discussion

Vagal paragangliomas are rare, but cause significant post-tumour excision morbidity as a result of unilateral vagal paralysis.<sup>5</sup> Multiple paragangliomas are common, especially in those with a family history of such tumours, and this results in a treatment dilemma as a subsequent synchronous contralateral lesion will cause airway obstruction due to bilateral vocal fold paralysis.<sup>1</sup> Selective reinnervation has been reported as a treatment option for bilateral vocal fold paralysis to re-establish vocal fold abduction, in order to improve the glottal airway and preserve the voice. Therefore, selective laryngeal reinnervation is a potentially attractive option to rehabilitate post-operative morbidities.

Both patients described in this paper demonstrated improvement of voice and swallowing following selective laryngeal reinnervation. Patients' perceptions regarding its effects on the physical, functional and emotional aspects of voice (assessed using the voice handicap index 10) and swallowing (examined using the Eating Assessment Tool 10) returned to a normal range at 12 months post-reinnervation. From one to six months after tumour excision, their voice and swallowing were helped temporarily by bulking up the vocal fold with collagen injections. Both of the patients had enteral feeding for one week only, and neither patient had aspiration pneumonia throughout follow up. Regarding the glottal airway, there was slight abduction observed in patient one and no obvious vocal fold abduction in patient two. Nevertheless, using the phrenic nerve for selective reinnervation did not cause significant morbidity to pulmonary function in the present study.

Laryngeal reinnervation (non-selective) has been reported to improve voice and swallowing in patients with unilateral vagal paralysis following vagal paraganglioma excision. In retrospective studies, Lee *et al.*<sup>15</sup> and Lorenz *et al.*<sup>16</sup> examined a similar population of patients, who underwent ansa to RLN reinnervation immediately after tumour removal. They documented a favourable outcome of ansa to RLN anastomosis, characterised by improvements in patients' voice perception and acoustic analysis, a long lasting improvement in glottic closure, and maintenance of the vocal fold edge.<sup>15,16</sup> However, in these studies, analysis of the patients' data was problematic: the pre-operative data were unavailable because the voice was normal prior to tumour resection.

Lamarre *et al.* reported a case of vagal paraganglioma resection with primary reinnervation of the larynx conducted in the same sitting.<sup>8</sup> In addition to ansa to RLN anastomosis, cricothyroid to cricothyroid reinnervation and greater auricular

nerve to superior laryngeal nerve anastomosis were performed. The patient showed good glottic closure at 12 months post-operatively and recovered swallowing function, but the measurements were not explicitly reported. To date, there have been no published attempts at selective reinnervation to the posterior cricoarytenoid to re-establish vocal fold abduction in this group of patients.

Selective reinnervation in the present study successfully improved the voice and swallowing, but failed to re-establish significant vocal fold abduction. This may be due to laryngeal synkinesis or the inability of axons from the phrenic nerve to trigger the abduction movement.

- Unilateral vagal paralysis following vagal paraganglioma excision leads to dysphonia, dysphagia and aspiration
- Excision of bilateral vagal paraganglioma at different time points may result in bilateral vocal fold paralysis requiring tracheostomy
- Injection laryngoplasty, medialisation thyroplasty, arytenoid adduction and laryngeal reinnervation are indicated to manage voice and swallowing
- Laryngeal reinnervation can be performed in the same sitting as vagal paraganglioma excision to minimise morbidity
- Selective reinnervation using the phrenic nerve did not cause significant pulmonary function morbidity
- Two patients had voice and swallowing improvements following selective reinnervation, but no significant vocal fold abduction

This study demonstrates the applicability of performing immediate selective reinnervation in the same sitting as vagal paraganglioma excision, to reduce post-operative morbidity. It re-established the tone and bulk of the denervated muscle, and thus improved the voice and swallowing to normal or near-normal. Theoretically, the successful re-establishment of vocal fold abduction will prevent future dilemmas regarding treatment should the tumour grow on the opposite side. Phrenic nerve split arguably should be replaced with another technique, such as that introduced by Marie and colleagues which uses the root of the phrenic nerve (C4),<sup>17,18</sup> or that described by Orestes *et al.* which uses the superior laryngeal nerve.<sup>19</sup>

## Conclusion

Selective reinnervation is safe to perform following vagal paraganglioma excision conducted on the same side. Voice and swallowing improvements were demonstrated, but no significant vocal fold abduction was achieved. Future studies should probably use the superior laryngeal nerve or the root of the phrenic nerve, instead of the split phrenic nerve technique.

**Competing interests.** None declared.

## References

- 1 Lozano FS, Gómez JL, Mondillo MC, González-Porras JR, González-Sarmiento R, Muñoz A. Surgery of vagal paragangliomas: six patients and review of literature. *Surg Oncol* 2008;**17**:281–7
- 2 Gilmer-Hill HS, Kline DG. Neurogenic tumors of the cervical vagus nerve: report of four cases and review of the literature. *Neurosurgery* 2000;**46**:1498–503
- 3 Miller RB, Boon MS, Atkins JP, Lowry LD. Vagal paraganglioma: the Jefferson experience. *Otolaryngol Head Neck Surg* 2000;**122**:482–7
- 4 Urquhart AC, Johnson JT, Myers EN, Schechter GL. Glomus vagale. *Laryngoscope* 1994;**104**:440–5

- 5 Netterville JL, Jackson C, Miller FR, Wanamaker JR, Glasscock ME. Vagal paraganglioma: a review of 46 patients treated during a 20-year period. *Arch Otolaryngol Head Neck Surg* 1998;**124**:1133–40
- 6 Fang TJ, Tam YY, Courey MS, Li HY, Chiang HC. Unilateral high vagal paralysis: relationship of the severity of swallowing disturbance and types of injuries. *Laryngoscope* 2011;**121**:245–9
- 7 Bielamowicz S, Gupta A, Sekhar LN. Early arytenoid adduction for vagal paralysis after skull base surgery. *Laryngoscope* 2000;**110**:346–51
- 8 Lamarre ED, Lorenz RR, Milstein C, Scharpf J. Laryngeal reinnervation after vagal paraganglioma resection: a case report. *Am J Otolaryngol* 2011;**32**:171–3
- 9 Woodson GE. Spontaneous laryngeal reinnervation after recurrent laryngeal or vagus nerve injury. *Ann Otol Rhinol Laryngol* 2007;**116**:57–65
- 10 Rosen CA, Lee AS, Osborne J, Zullo T, Murry T. Development and validation of the voice handicap index-10. *Laryngoscope* 2004;**114**:1549–56
- 11 Mat Baki M, Wood G, Alston M, Ratcliffe P, Sandhu G, Rubin JS *et al*. Reliability of OperaVOX against Multidimensional Voice Program (MDVP). *Clin Otolaryngol* 2015;**40**:22–8
- 12 Crumley RL, Horn K, Clendenning D. Laryngeal reinnervation using the split-phrenic nerve-graft procedure. *Otolaryngol Head Neck Surg* 1980;**88**:159–64
- 13 Crumley RL, Izdebski K. Voice quality following laryngeal reinnervation by ansa hypoglossi transfer. *Laryngoscope* 1986;**96**:611–16
- 14 Rosen CA. Stroboscopy as a research instrument: development of a perceptual evaluation tool. *Laryngoscope* 2005;**115**:423–8
- 15 Lee WT, Milstein C, Hicks D, Akst LM, Esclamado RM. Results of ansa to recurrent laryngeal nerve reinnervation. *Otolaryngol Head Neck Surg* 2007;**136**:450–4
- 16 Lorenz RR, Esclamado RM, Teker AM, Strome M, Scharpf J, Hicks D *et al*. Ansa cervicalis-to-recurrent laryngeal nerve anastomosis for unilateral vocal fold paralysis: experience of a single institution. *Ann Otol Rhinol Laryngol* 2008;**117**:40–5
- 17 Marina MB, Marie JP, Birchall MA. Laryngeal reinnervation for bilateral vocal fold paralysis. *Curr Opin Otolaryngol Head Neck Surg* 2011;**19**:434–8
- 18 Remacle M, Eckel HE. *Surgery of Larynx and Trachea*. Heidelberg: Springer, 2010
- 19 Orestes MI, Chhetri DK, Berke G. Selective reinnervation for bilateral vocal cord paralysis using the superior laryngeal nerve. *Laryngoscope* 2015;**125**:2547–50