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Airflow in unilateral vocal cord paralysis before and after Teflon injection

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Cormier, Y., Kashima, H., Summer, W., and Menkes, H. (1978). *Thorax*, **33**, 57–61. **Airflow in unilateral vocal cord paralysis before and after Teflon injection.** The effect of unilateral vocal cord paralysis and intracordal Teflon injection on maximum expiratory and inspiratory flows was studied in 15 consecutive patients. Ten patients had a ratio of forced expiratory flow to forced inspiratory flow at 50% vital capacity ($\dot{V}e_{50}/\dot{V}i_{50}$) more than one. Of the remaining five, four had low $\dot{V}e_{50}$ consistent with underlying bronchial disease. Repeat studies were obtained in 10 patients two or more weeks after Teflon injection into a vocal cord for voice therapy. Maximum expiratory flow rates did not change (means $6 \cdot 64 \pm 0 \cdot 88$ l/sec before and $6 \cdot 47 \pm 1 \cdot 10$ l/s after injection). Inspiratory flow at 50% vital capacity improved in all six patients with a forced expiratory volume in one second (FEV_1) greater than 75% of the forced vital capacity (FVC). In patients with an FEV_1 less than 75% FVC, no consistent changes could be seen. We conclude that a high $\dot{V}e_{50}/\dot{V}i_{50}$ suggestive of variable extrathoracic airways obstruction is a frequent finding in the presence of unilateral vocal cord paralysis. Teflon injection does not cause a significant reduction in forced expiratory flows and improves inspiratory flows in subjects without evidence of underlying bronchial disease.

Bilateral vocal cord paralysis is a well-documented cause of variable extrathoracic airways obstruction (Miller and Hyatt, 1973; Yernault *et al.*, 1973). The effect of unilateral vocal cord paralysis on airflows is poorly documented (Shim *et al.*, 1972). Schiratzki (1965) reported an increase in mouth to subglottic resistance in females with unilateral recurrent nerve paralysis although he found no increase in males. Physiological studies after Teflon injection have not, to our knowledge, been reported.

The injection of Teflon into a vocal cord for vocal rehabilitation of paralytic dysphonia was first reported by Arnold (1961). This technique has now become the treatment of choice for symptoms of permanent unilateral vocal cord paralysis. The object of the procedure is to improve vocal function and reduce aspiration. Enough Teflon paste is injected into the paralysed cord to create a rigid structure against which the normal vocal cord opposes during phonation. Results have been excellent (Lewy, 1963, 1976; Rubin, 1965a, b), with voice improvement reported in up to 96% of patients, and similar success in reducing the evidence of aspiration (Dedo *et al.* 1973; Rontal *et al.*, 1976).

Complications have been rare and usually transient. Occasional mild stridor can occur after the injection; this is attributed to oedema and usually regresses in a few days. Reactive oedema sufficient to require tracheostomy is rare. The reported cases of acute airways obstruction were not documented by airflow studies.

The long-term effect of this foreign body on airflows has not been evaluated. Does the injection of Teflon into a paralysed vocal cord compromise the functions of the vocal box as an airway? To answer this question, and to clarify the physiological effect of unilateral vocal cord paralysis on maximal airflows, we describe airflow studies in 15 patients with unilateral vocal cord paralysis, 10 of whom underwent Teflon injection.

Material and methods

Nineteen consecutive patients referred to The Johns Hopkins Hospital Otolaryngology Service with unilateral vocal cord paralysis were studied. Four

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patients in whom we were unable to obtain reproducible data were eliminated from the study. The remaining 15 patients are reported in this paper. Ten patients were available for study after Teflon injection, one had spontaneous recovery, two refused injection, and two were lost to follow-up.

Measurements of forced inspiratory and expiratory flows were performed with a waterless spirometer (CPI model 220). Flow volume loops were stored on an oscilloscope and transcribed onto graph paper with an oscillotracer. All values were corrected to BTPS. Results presented are the highest values from three reproducible forced respiratory manoeuvres. Teflon injections were performed by one of us (HK). The patients were admitted to hospital and the injection was performed while laryngeal exposure was maintained by Suspension Laryngoscopy. Topical anaesthesia (4% xylocaine) was used and supplemented by intravenous diazepam. Teflon paste, 0·2–0·6 ml, was injected with a Bruning syringe into the mid-portion of the membraneous vocal cord until the desired vocal cord contour was achieved (Arnold, 1961). The laryngoscope was withdrawn and the patient's voice checked. Mirror laryngoscopy was performed to verify that the vocal cords approximated during phonation. When necessary, the direct laryngoscopy was repeated for supplemental injection. The patient was asked to rest his voice and was discharged from hospital on the morning after the operation. Post-injection studies were obtained two or more weeks after the Teflon injection.

Results

Clinical data are presented in Table 1. Presenting symptoms were usually those of hoarseness. Five patients also complained of aspiration. Most patients noted shortness of breath while speaking. Of the 10 patients who received Teflon injection and were available for follow-up, none had clinically apparent acute airways obstruction after injection. All patients who complained of aspiration before the injection claimed relief after the procedure. Good subjective voice improvement was achieved in seven of the 10 patients.

Results of pulmonary function tests are presented in Table 2. The patients are listed in order of increasing $FEV_1\%$. Five patients had spirometric evidence of underlying disease. Four had airways obstruction with an FEV_1/FVC less than 70% and one (LS) had a reduced forced vital capacity probably secondary to previous resective surgery for histoplasmosis.

The significance of functional changes following Teflon injection was assessed with the standard *t* test. In the group as a whole a significant improvement ($P<0·05$) of forced expiratory flows at 50% vital capacity ($\dot{V}e_{50}$) was seen. In the individual subject, increases were small. However, maximum expiratory flows were not significantly improved by the injection. No significant changes in forced expiratory flows were noted after Teflon injection although all subjects with an $FEV_1\%>75\%$ before injection showed improvement. A ratio of forced expiratory to forced inspira-

Table 1 *Clinical data of the patients*

Name	*Aetiology*	*Smoking history*	*Presenting symptoms*	*Clinical results (subjective)*		*Time between injection and second tests*
				Voice	*Aspiration*	
JF	Post left upper lobectomy cancer	30 pk yr	Hoarseness	Good		5 weeks
EG	Post ventriculojugular shunt	0	Hoarseness	Good		5 weeks
ET	Idiopathic	0	Hoarseness			
RP	Neurofibroma	40 pk yr	Hoarseness Aspiration	Good	Good	7 months
JBEZ	Thyroid operation for cancer	0	Hoarseness	Fair		19 months
RB	Idiopathic	30 pk yr	Hoarseness Aspiration			
LS	Left pneumonectomy for histoplasmosis	0	Hoarseness Aspiration	Good	Good	3 months
SK	Thyroid surgery	0	Hoarseness Aspiration	Good	Good	5 months
LB	Cricoid cartilage chondroma	Unknown	Hoarseness Aspiration			
HM	Post thyroid operation	10 cigars/day	Hoarseness	Good		7 weeks
DF	Thyroid operation	0	Hoarseness			
JS	Post anterior cervical fusion	0	Hoarseness Aspiration	No improvement	Good	5 weeks
JBLA	Postoperative neck cyst	0	Hoarseness Aspiration	Good	Good	8 months
JN	Laryngeal trauma	0	Hoarseness	No improvement		4 months
BS	Idiopathic	0	Hoarseness			

Table 2 *Results of spirometric measurements and flow volume loops*

Patient		*FVC* (*l*)	*% Pred*	*FEV*$_1$ (*l*)	*FEV*$_1$/*FVC* (%)	$\dot{V}i_{max}$ (*l/sec*)	$\dot{V}i_{50}$ (*l/sec*)	$\dot{V}e_{max}$ (*l/sec*)	$\dot{V}e_{50}$ (*l/sec*)	$\dot{V}e_{50}/\dot{V}i_{50}$
JF	Pre	4·33	91	2·69	62	4·8	4·8	6·3	1·7	0·35
	Post	4·62	97	2·97	64	3·4	2·9	4·5	2·6	0·90
EG	Pre	2·76	77	1·75	63	2·6	2·4	2·3	1·7	0·70
	Post	2·69	75	1·60	60	2·2	1·9	1·9	1·7	0·93
ET		3·26	101	2·15	66	1·7	1·6	2·4	2·0	1·25
RP	Pre	4·08	93	2·85	70	2·3	2·2	5·6	2·9	1·32
	Post	4·08	93	2·78	68	3·9	3·9	4·2	3·2	0·82
JB	Pre	4·17	127	3·02	72	3·5	3·5	6·3	3·4	0·97
	Post	3·54	109	2·68	76	3·2	3·1	5·6	3·2	1·03
RB		4·45	98	3·41	76	4·5	4·2	11·8	3·2	0·76
LS	Pre	2·13	62	1·62	76	2·4	2·4	4·6	1·7	0·71
	Post	2·15	63	1·61	75	3·4	3·3	4·9	1·6	0·48
SK	Pre	4·45	111	3·49	78	4·2	3·9	9·2	4·3	1·10
	Post	5·16	128	3·83	74	5·8	5·2	10·2	4·6	0·88
LB		4·59	107	3·61	79	3·1	2·9	10·2	4·4	1·52
HM	Pre	4·96	108	3·73	80	4·0	3·6	7·3	4·9	1·36
	Post	5·23	114	4·07	80	5·1	4·5	8·3	6·4	1·42
DF		2·52	81	2·03	81	2·4	1·0	6·2	3·0	3·00
JS	Pre	4·81	100	4·11	86	7·0	6·4	12·8	8·3	1·30
	Post	4·85	101	4·30	88	8·5	8·4	14·0	9·7	1·15
JB	Pre	3·73	99	3·29	88	2·8	2·7	6·3	4·7	1·74
	Post	3·65	94	3·10	85	3·0	2·9	5·1	4·9	1·69
JN	Pre	3·88	102	3·43	88	2·7	2·5	5·7	5·2	2·08
	Post	3·94	103	3·46	88	3·6	3·3	6·0	5·5	1·67
BS		2·73	84	2·55	93	2·8	2·6	4·2	4·2	1·62
Mean	Pre	3·93		3·00	76·3	3·63	3·44	6·64	3·88	
	Post	3·99		3·04	75·8	4·21	3·94	6·47	4·34	
	SE	0·11		0·08	0·81	0·31	0·37	0·34	0·18	
		NS		NS	NS	NS	NS	NS	$P < 0·05$	

FVC = forced vital capacity; FEV$_1$ = forced expiratory volume in one second; $\dot{V}i_{max}$ = maximum inspiratory flow; $\dot{V}i_{50}$ = forced inspiratory flow at 50% vital capacity; $\dot{V}e_{max}$ = maximum expiratory flow; $\dot{V}e_{50}$ = forced expiratory flow at 50% vital capacity.

tory flow at 50% vital capacity greater than one ($\dot{V}e_{50}/\dot{V}i_{50} > 1$) (Miller and Hyatt, 1973; Yernault *et al.*, 1973) was present in 10 of our 15 patients with unilateral vocal cord paralysis. This finding was present in four of the 10 patients who were subsequently studied after Teflon injection.

Discussion

It has been repeatedly shown that bilateral vocal cord paralysis often creates a significant variable extrathoracic airways obstruction. On the other hand, the physiological effect of unilateral vocal cord paralysis has been poorly documented. The first objective of this study was to evaluate the effect of unilateral vocal cord paralysis on maximal airflows. Ten of our 15 patients had $\dot{V}e_{50}/\dot{V}i_{50} > 1$. This, according to Miller and Hyatt (1969), is suggestive of a variable extrathoracic obstruction. In three of the five patients who did not have this increased ratio, $\dot{V}e_{50}$ was probably reduced by underlying bronchial disease (Bass, 1973). In this setting, the ratio $\dot{V}e_{50}/\dot{V}i_{50}$ may not adequately identify patients with decreased inspiratory flows. All eight patients with FEV$_1$/FVC% > 76% had a ratio of more than one. One patient (RB) who did not meet the criteria $\dot{V}e_{50}/\dot{V}i_{50} > 1$ had a spontaneous recovery of his paralysed cord. His inspiratory flows at 50% VC increased from 4·2 to 6·9 l/s (after recovery), demonstrating that unilateral vocal cord paralysis caused a reduction in inspiratory flows, and that in the presence of reduced $\dot{V}e_{50}$, because of underlying

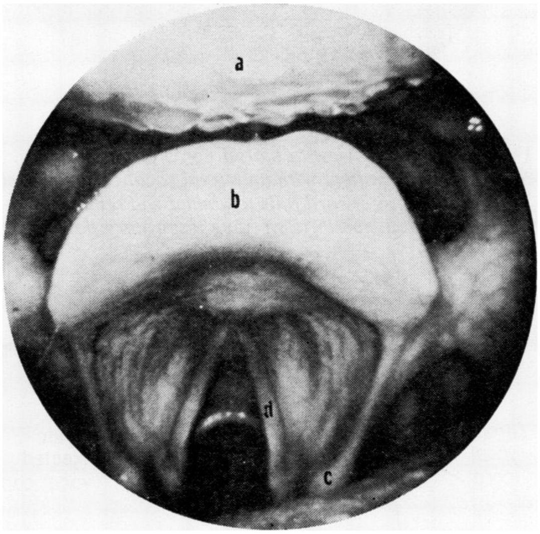

Fig. 1 *Direct laryngoscopic view of normal vocal cords during forced inspiration: (a) base of the tongue, (b) epiglottis, (c) arytenoids, (d) right vocal cord.*

lung disease, the ratio $\dot{V}e_{50}/\dot{V}i_{50}$ may not identify this reduction.

Figures 1 and 2 illustrate how a unilateral paralysed vocal cord can impede inspiratory flows. During forced inspiration, normal vocal cords abduct maximally (Fig. 1). In the presence of a vocal cord paralysis, the paralysed cord is left in a resting paramedian position to impede maximal inspiratory flows (Fig. 2a). During forced expiration (Fig. 2b) the paralysed cord is deflected from its resting position and thus does not reduce expiratory airflows. Owing to the anatomy and position of the vocal cords (Lemere, 1933), a paralysed cord may act like the sail of a schooner and catch the wind in one direction. This tends to move the paralysed cord towards the midline (Fig. 3). During expiration the paralysed cord will be displaced laterally by the air current.

The second objective of our study was to evaluate the effect of Teflon injection on airflows. It seemed reasonable to assume that injecting Teflon into a paralysed cord would impede maximal airflow. It is noteworthy that, in this series of patients, Teflon injection did not produce significant reduction in expiratory flow. In fact, in no patient did it produce an expiratory pattern typical for a fixed extrathoracic airways obstruction (Yernault *et al.*, 1973). There was no peak flow cut-off during forced expiration, and no difference in peak expiratory flows before and after surgery.

Although maximal inspiratory flow ($\dot{V}i_{max}$) and

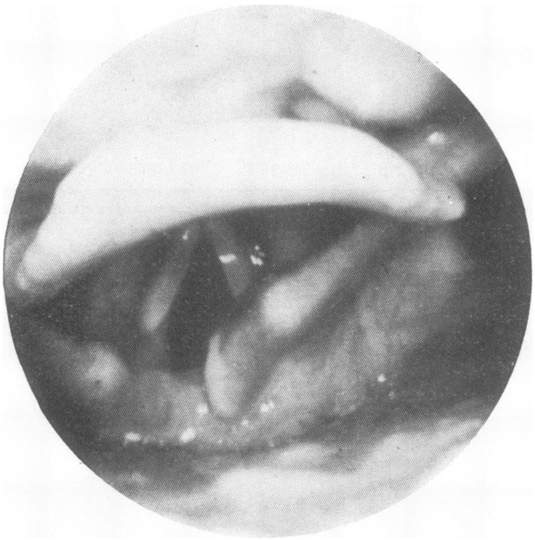

Fig. 2(a) *Similar view to that in Fig. 3 during forced inspiration in a patient with unilateral vocal cord paralysis. The paralysed right cord fails to abduct and remains in a midline position, possibly impeding inspiratory flows.*

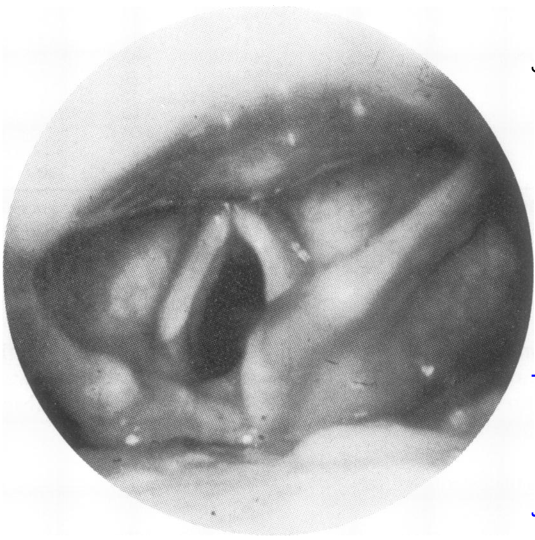

Fig. 2(b) *Same patient as in Fig. 2(a). Vocal cords during forced expiration. The paralysed right cord takes a concave curvature. Airflow during forced expiration pushes the paralysed cord laterally.*

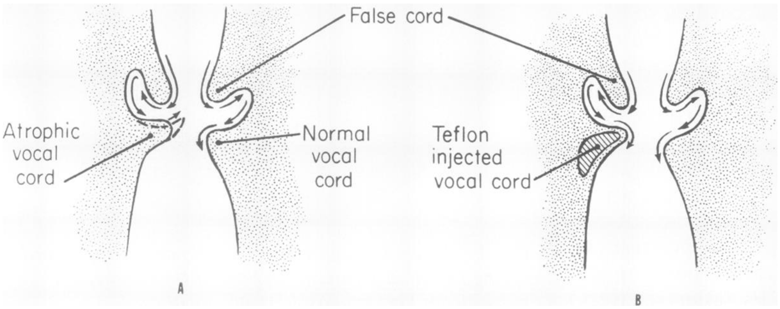

Fig. 3 *Diagram representing a cross-sectional view of the larynx: (left) effect of inspiratory air turbulence on the paralysed cord; (right) Teflon injection fixes the paralysed cord and may prevent this 'sail phenomenon'.*

$\dot{V}i_{50}$ did not significantly improve in the group as a whole, all six patients with an FEV_1% more than 75% had improved inspiratory flows after Teflon injection. These results indicate that, in patients without evidence of underlying lung disease, an improvement in inspiratory flows after Teflon injection was demonstrable. Figure 3 shows the physical effect of Teflon injection into a vocal cord. Teflon renders the cord more rigid and may prevent the paralysed cord from moving towards the midline. This could account for improved inspiratory flows after Teflon injection.

Physiological evidence of obstruction to forced inspiratory flows is thus a frequent finding in patients with unilateral vocal cord paralysis. Teflon paste injection into a paralysed vocal cord as treatment for paralytic dysphonia is a safe procedure and exerts no long-term limiting effect on forced expiratory flows. Our data suggest that Teflon injection may actually improve forced inspiratory flow.

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