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**VELOPHARYNGEAL AERODYNAMICS FOLLOWING BILATERAL
SUBTHALAMIC NUCLEUS DEEP BRAIN STIMULATION
in PARKINSON'S DISEASE**

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**Abstract: VELOPHARYNGEAL AERODYNAMICS FOLLOWING BILATERAL
SUBTHALAMIC NUCLEUS DEEP BRAIN STIMULATION in PARKINSON'S
DISEASE**

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The efficacy of bilateral subthalamic nucleus (STN) deep brain stimulation (DBS) on velopharyngeal (VP) aerodynamics was studied in eighteen patients with idiopathic Parkinson's disease (PD). Adequate VP closure during speech production depends on approximation of the velum with the lateral and posterior pharyngeal walls to an orifice area less than 5 mm². Individuals with PD often exhibit disorders in timing, extent and coordination of VP function. Measures were made of intraoral pressure (P_o), peak VP airflow (P-Flow), VP resistance (VPR) and estimates of VP area (VPA) to characterize VP function. Although not always positive, initial results reveal substantial reorganization of VP function in speech motor control. These data further support the notion that changes in motor drive associated with the hypokinetic dysarthria of PD and the treatment effect of DBS impose change in motor drive across multiple components of the vocal tract.

Summary

Velopharyngeal (VP) aerodynamics is a sensitive clinical tool for assessment of VP function during speech production. Adequate VP closure to an orifice area of less than 5mm^2 during production of non-nasal phonemes depends on approximation of the velum with the lateral and posterior pharyngeal walls. Adequate extent and appropriate timing of VP closure depends upon anatomical structure and neurological integrity. Individuals with PD often exhibit abnormal timing and magnitude of VP movement characterized by hypernasality, decreased intraoral pressure (P_o), increased VP airflow and decreased VP resistance (Darley, Aronson & Brown, 1975; Hooding & Gilbert, 1989; Logemann et al., 1986; Robbins, Logemann & Kirshner, 1986). The purpose of the present study was to quantitatively study $N = 18$ surgical candidates with Parkinson's disease using VP aerodynamics.

P_o and nasal airflow were transduced and VP resistance (VPR) and VP area (VPA) were calculated based on techniques described previously (Baken & Orlikoff, 2000; Barlow, Suing & Andreatta, 1999; Warren & DuBois, 1964). Data were collected for 18 patients with mean age of 59;47, ranging from 36 to 76 years of age. Subjects were tested without their antiparkinsonian medication under two conditions of deep brain stimulation: Stimulation OFF and Stimulation ON. Measures were made of intraoral pressure (P_o), peak VP airflow (P-Flow), VP resistance (VPR) and estimates of VP area (VPA) to characterize VP function. For each of the eighteen patients tested, differences between mean values for each measure were compared using Student's t-test with a significance level of $p = 0.05$. Results varied and the distribution of outcomes is displayed below.

P_o : Higher = 39%, Lower = 11%, No Difference = 50%

VP-FLOW: Less = 22%, More = 17%, No Difference = 61%

VP AREA: Less = 22%, More = 17%, No Difference = 61%

VP Resistance: Higher = 11%, Lower = 11%, No Difference = 78%

The data described for the following three subjects (**B2, C1, A2 and B8**) further demonstrate the substantially different results observed.

Subject B2 presented with a positive result from the DBS surgery. P_o values changed modestly from $3.98\text{ cmH}_2\text{O}$ (OFF) to $4.88\text{ cmH}_2\text{O}$ (ON). VPA changed dramatically from 36.80

mm² (OFF) to an adequate area of 3.85 mm² (ON). This represents a ten-fold reduction in area of the VP orifice and was accompanied by a reduction in P-Flow from 71.30 cc/sec (OFF) to 8.53 cc/sec (ON) and is consistent with changes in VPR from 66.10 Ohms (OFF) to 1315 Ohms (ON). This patient reflected dramatic reorganization of the VP mechanism with DBS. Severe VP inadequacy changed to a normal level of VP function.

Subjects C1 & A2 reflected non-significant differences between DBS ON & OFF states. **Subject C1** exhibited normal values for P_o of 7.06 cm H₂O (OFF) and 8.94 cm H₂O (ON). Normal VPA values were also within normal limits at 0.50 mm² (OFF) and 0.72 mm² (ON), and were accompanied by P-Flow values of 1.22 cc/sec (OFF) and 2.13 (ON). Similarly, VPR values were 7181 Ohms (OFF) and 6478 Ohms (ON) reflecting no significant changes in VP function.

Subject A2 exhibited similar subnormal P_o values of 4.37 cmH₂O (OFF) and 3.82 cmH₂O (ON). Although statistically not significant, VPA increased from an abnormally large 43.20 mm² (OFF) to 76.30 mm² (ON) and was accompanied by P-Flow of 88 cc/sec (OFF) and 114 cc/sec (ON). Corresponding VPR values were 51.80 Ohms (OFF) and 39.50 Ohms (ON). Despite the non-significance of the changes observed, these data demonstrated increasing physiological severity of an already severe degree of VP inadequacy.

Subject B8 demonstrated a significant negative outcome for VP aerodynamics. Subnormal P_o values were similar at 5.48 cm H₂O (OFF) and 5.59 cm H₂O (ON). Significant increases were observed in VPA changing from an already inadequate 22.70 mm² (OFF) to 32 mm² (ON) and P-Flow increasing from 50.40 cc/sec (OFF) to 73.90 cc/sec (ON). VPR values decreased significantly from 161 Ohms (OFF) to 93.2 Ohms (ON). These data provide another example of increasing VP inadequacy with DBS.

In assessing the efficacy of DBS on speech motor control in patients with PD, use of VP aerodynamics provides a sensitive and non-invasive technique to examine the air pressure and airflow dynamics associated with VP activity in motor speech production. Although not always positive, in some cases there was dramatic reorganization of VP motor drive. This was similar to findings in respiratory and laryngeal subsystems (Barlow, Hammer, Pahwa & Seibel, 2003). Further work is currently in progress to examine the effect of PD and DBS on forelimb, orofacial and *timing* of velopharyngeal physiology.

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