LARYNGEAL ENGAGEMENT FOLLOWING BILATERAL SUBTHALAMIC NUCLEUS DEEP BRAIN STIMULATION IN PARKINSON’S DISEASE

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Abstract: LARYNGEAL ENGAGEMENT 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 the aerodynamics of laryngeal engagement was studied in nineteen patients with idiopathic Parkinson’s disease (PD). Laryngeal engagement (LE) during spoken production of a consonant-vowel syllable (e.g. /pa/) is defined as the transition from the plosive burst-release of the consonant to the onset of voicing in the vowel. Intrinsic laryngeal muscle activity responsible for LE consists of relative quiescence of the muscles of abduction, and contraction of the muscles of adduction resulting in approximation of the vocal folds at the midline above the respiratory airstream, and subsequent vocal fold oscillation in response to positive subglottal air pressure (P$_s$). Patients with PD often exhibit impairment in the alternation between phonatory onset and offset during connected speech and suffer from increased effort required for speech communication. Although not always positive, initial results reveal substantial reorganization of laryngeal and respiratory subsystems in speech motor control. Correlation analyses 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

Laryngeal engagement (LE) during spoken production of the consonant-vowel syllable /pa/ is defined as the transition from the plosive burst-release of the consonant to the onset of voicing (Barlow, Paseman & Philippar, 1999). Intrinsic laryngeal muscle activity responsible for LE consists of relative quiescence of the muscles of abduction, contraction of the muscles of adduction resulting in approximation of the vocal folds at the midline above the respiratory airstream, and subsequent vocal fold oscillation in response to positive subglottal air pressure ($P_s$). Patients with PD often exhibit impairment in the alternation between phonatory onset and offset during connected speech and suffer from increased effort required for speech communication (Gallena, Smith, Zeffiro & Ludlow, 2001). The purpose of the present study was to quantitatively study N = 19 surgical candidates with Parkinson’s disease using the aerodynamics of laryngeal engagement.

$P_s$ and translaryngeal airflow were transduced and laryngeal airway resistance (LR) was calculated based on techniques described previously (Barlow, Suing & Andreatta, 1999; Smitheran & Hixon, 1981). Data were collected for 19 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. Airflow arrays under each condition for spoken productions of /pa/ at 2 syllables per second were averaged and graphically displayed with 95% confidence intervals. Array subtraction was performed and differences in flow rate (cc/sec) and volume loss (cc) were calculated and displayed for each subject. For the nineteen patients tested, differences between ON vs. OFF mean values for $P_s$, peak translaryngeal airflow (P-Flow), mean translaryngeal airflow (V-Flow), and LR were calculated to examine change in vocal tract physiology between conditions. Results varied and
the distribution of outcomes is displayed below (Barlow, Hammer, Pahwa & Seibel, 2003; Barlow, Hammer, Pahwa, Park, Seibel et al., 2002; Hammer, Barlow, Seibel & Estep, 2002).

- **P**: No Change = 47%, Worse = 37%, Improved = 16%
- **P-Flow**: No Change = 32%, Worse = 26%, Improved = 42%
- **V-Flow**: No Change = 47%, Worse = 37%, Improved = 16%
- **LR**: No Change = 36%, Worse = 32%, Improved = 32%

Additional information regarding vocal tract physiology was gleaned by further examining the details of the airflow arrays. For each airflow array, a 100ms-wide window was selected beginning at the peak in the airflow array (marking the onset of LE) through the region of the waveform representing established steady-state phonation. Each selected segment was regressed using a cubic fit and displayed for comparison between DBS conditions. For each subject, a formal comparison of regression lines was performed to examine the uniqueness of the intercepts and slopes. The change (ON – OFF) between intercepts (dInt) and slopes (dSlope) was calculated for each subject and revealed the same trend for both intercept and slope.

- **Intercept** DBS ON > DBS OFF = 52.63%
- **Intercept** DBS OFF > DBS ON = 36.84%
- **Intercept** No Sig Diff = 10.53%
- **Slope** DBS ON > DBS OFF = 52.63%
- **Slope** DBS OFF > DBS ON = 36.84%
- **Slope** No Sig Diff = 10.53%

Pearson product moment correlations were calculated to examine the relationship between changes in slope and intercept of the flow arrays with changes in other mean values derived from laryngeal aerodynamics. PD subjects with globally decreased motor drive of
vocal tract (intercept) tended to exhibit decreased motor drive of both respiratory (Ps and P-Flow) and laryngeal (LR) subsystems. These same subjects also exhibited substantially decreased speed of LE (slope) and increased leakage (V-Flow) of respiratory supply through the larynx consistent with decreased approximation of the vocal folds. In contrast, subjects with relatively strong vocal tract motor drive (intercept) demonstrated considerable increases in motor drive to respiratory (Ps and P-Flow) and laryngeal (LR) mechanisms accompanied by increased speed of LE (slope) and more efficient utilization of respiratory supply by the larynx (V-Flow) due to increased closure of the vocal folds.

To examine the relationship among changes in the physiological measures of vocal tract subsystems (dPs, dP-Flow, dV-Flow, dLR), Pearson product moment correlations were calculated. These relationships were consistent with the notion that changes in motor drive associated with either the hypokinetic dysarthria of PD or the treatment effect of DBS impose change in motor drive across multiple components of the vocal tract. Patients who exhibited changes in motor drive from DBS in one subsystem of the vocal tract appeared to exhibit similar changes in motor drive across the entire vocal tract.

Cited Literature


