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Comparison of voluntary and reflex cough effectiveness in Parkinson's disease

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ABSTRACT

Introduction: Multiple airway protective mechanisms are impacted with Parkinson's disease (PD), including swallowing and cough. Cough serves to eject material from the lower airways, and can be produced voluntarily (on command) and reflexively in response to aspirate material or other airway irritants. Voluntary cough effectiveness is reduced in PD however it is not known whether reflex cough is affected as well. The goal of this study was to compare the effectiveness between voluntary and reflex cough in patients with idiopathic PD.

Methods: Twenty patients with idiopathic PD participated. Cough airflow data were recorded via face-mask in line with a pneumotachograph. A side delivery port connected the nebulizer for delivery of capsaicin, which was used to induce cough. Three voluntary coughs and three reflex coughs were analyzed from each participant. A two-way repeated measures analysis of variance was used to compare voluntary versus reflex cough airflow parameters.

Results: Significant differences were found for peak expiratory flow rate (PEFR) and cough expired volume (CEV) between voluntary and reflex cough. Specifically, both PEFR and CEV were reduced for reflex as compared to voluntary cough.

Conclusion: Cough PEFR and CEV are indicative of cough effectiveness in terms of the ability to remove material from the lower airways. Differences between these two cough types likely reflect differences in the coordination of the respiratory and laryngeal subsystems. Clinicians should be aware that evaluation of cough function using voluntary cough tasks overestimates the PEFR and CEV that would be achieved during reflex cough in patients with PD.

1. Introduction

The cough motor pattern comprises a highly coordinated sequence of respiratory and laryngeal muscle contractions resulting in a high rate of expiratory airflow. The cough pattern is responsible for the shearing forces utilized to eject material from the airway. The cough neural network is activated by stimulation of various airway afferents (reflex or induced cough) or alternatively by cortically mediated voluntary neural activation [1–3]. Both reflex and voluntary cough mechanisms initiate a sequence of similar cough motor behaviors, including the inspiratory, compression, and expulsive phases (Fig. 1).

Cough has long been studied as an important airway defense behavior, with more recent literature drawing attention to the relationship between cough and swallowing function. A “weak” voluntary cough is associated with increased likelihood of dysphagia in multiple patient populations [4,5]. In Parkinson's disease (PD), objective measures of reduced voluntary cough expiratory airflow parameters are strongly correlated to penetration and aspiration of bolus material during swallowing [6,7]. These cough impairments may be attributed to bradykinesia affecting the abdominal muscles, chest-wall rigidity, reduced central neural drive, and/or poor laryngeal valving, all of which are associated with PD [8,9] .

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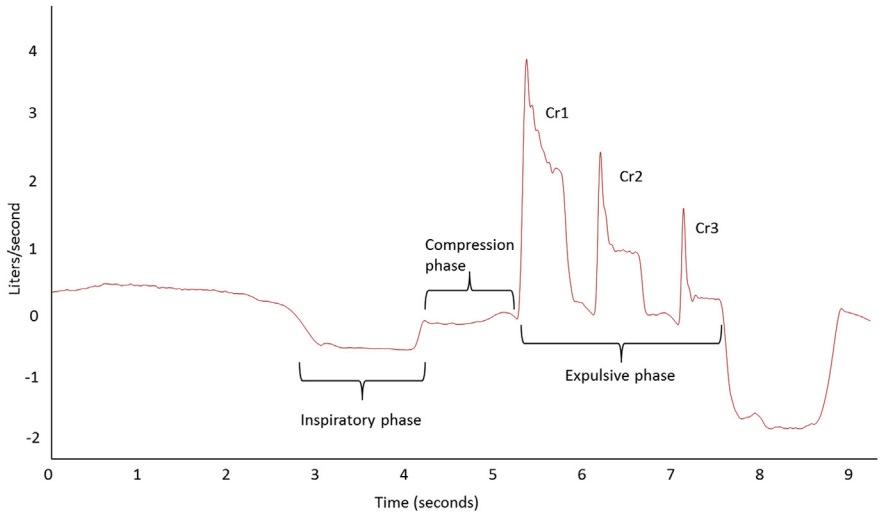

Fig. 1. Cough airflow waveform for a cough epoch containing 3 cough re-accelerations (Cr1, Cr2, and Cr3) in the expulsive phase.

Fewer empirical studies have investigated reflex cough function in PD. Fontana and colleagues found a reduction in peak abdominal EMG activity for both reflex and voluntary cough in PD when compared to healthy control participants [10]. These researchers observed that EMG activity rise time was *slower* for PD versus healthy age-matched control participants for both voluntary and reflexive cough, and that for the PD participants, the rate of EMG rise was further reduced for reflex as compared to voluntary cough. The authors hypothesized that the effects on EMG activity would correspond to increased time to reach peak airflow, and overall reduced airflow for voluntary and reflex cough in PD (it is important to note that these hypotheses were not tested in that study). Leow and colleagues also studied reflex cough in PD using citric acid as the tussigenic stimulus. These researchers focused on sensory thresholds associated with cough production in PD, and did not provide information on the expiratory airflows associated with reflex PD cough production [11].

There is evidence that both reflex and voluntary cough airflows are impaired with neurologic injury, including traumatic brain injury (TBI) [12] and stroke [13]. To date there has been no direct comparison of airflow measures between voluntary and reflex cough in PD. The performance of a volitional cough will be restrained by the ability to comprehend the task, initiate the task, and execute the task in the requisite coordinated fashion. This sequence could prove difficult in the PD population which is known to have difficulty with the initiation and coordination of voluntary motor tasks. In contrast, reflex cough has traditionally been considered a brainstem mediated response, and it may be that the more automatic nature of the task will be less affected by sequencing and coordination deficits. The goal of this study was to compare airflow parameters between reflex cough and voluntary cough in patients with idiopathic PD. We hypothesized that voluntary cough airflow measures, including peak airflow rate and total expired air, would be reduced, and cough compression phase duration prolonged as compared to reflex cough in PD. Further, we hypothesized that the time sequence of the cough produced (i.e., whether first or second) would influence these differences. Specifically, we hypothesized that the first cough produced would be significantly different between the two cough types, however the differences would not extend to the second cough produced. Understanding reflex and voluntary cough in PD could potentially impact prevention of aspiration pneumonia and counseling of at risk patients.

2. Methods

Approval for this study was granted from the University of Florida (UF) Health Science Center Institutional Review board. Twenty participants with idiopathic PD (14 males and 6 females, age M = 68.3 years, SD = 7.33) were recruited from the UF Center for Movement Disorders and Neurorestoration based on consecutive referral to the Speech-Language Pathology service over a three-month time period. The diagnosis of idiopathic PD was determined by a University of Florida neurologist fellowship trained in Movement Disorders and by use of the UK Brain Bank Criteria [14]. All participants provided written informed consent.

Exclusionary criteria were: 1) other neurological disorders (e.g., multiple sclerosis, stroke, brain tumor); 2) history of head, neck, or lung cancer; 3) history of chronic respiratory disorders or diseases (e.g. chronic obstructive pulmonary disease (COPD), asthma, emphysema); 4) history of smoking in the last five years; 5) uncontrolled hypertension; 6) difficulty complying due to neuropsychological or cognitive dysfunction.

2.1. Equipment

Cough airflow data were recorded via facemask in line with an antibacterial filter attached to a pneumotachograph (MLT 1000; ADInstruments, Inc). A side delivery port with a one-way inspiratory valve between the facemask and pneumotachograph allowed for nebulizer connection. The nebulizer was a DeVilbiss T-piece (DeVilbiss Healthcare, Inc.) connected to a dosimeter (Koko Dosimeter) that delivered aerosolized solution during inspiration with delivery duration of 2 s. The pneumotachograph input differential pressure change to the digital spirometer (ADInstruments, Inc), was digitized (PowerLab, ADInstruments, Inc) and recorded (LabChart 7, ADInstruments, Inc) for analysis. A 3-L syringe was used to calibrate airflow and volume.

Cough was induced using capsaicin ((E)-N-[(4-hydroxy-3-methoxyphenyl) methyl]-8-methyl-6-nonenamide) dissolved in a vehicle solution vehicle solution consisting of 80% physiological saline, and 20% ethanol. The capsaicin solution was diluted to concentrations of 50, 100, and 200 μm. The vehicle solution alone (80% physiological saline, 20% ethanol) was administered as a control aerosol (0 μM). For the purposes of this study, only coughs produced at the highest capsaicin concentration (200 μm) were included for comparison with voluntary cough. The rationale for this was based on our preliminary work in healthy adults showing 200 μm to be a supra-threshold level of capsaicin where reflex cough was consistently elicited. Because the study aimed to compare airflow parameters from reflex versus voluntary cough, it was appropriate to use only the supra-threshold level of capsaicin.

2.2. Procedures

All procedures were completed in a quiet clinic room with the participant seated upright in a chair. The facemask was held in place over the participant's nose and mouth by the experimenter or an assistant. First, 30 s of tidal breathing were recorded in order for participants to acclimate to the facemask. For reflex cough testing, participants were told that they would "inhale different levels, or concentrations, of a vapor that may or may not make you feel like you need to cough," with the instruction to "cough if you need to cough into the facemask." Three presentations of each capsaicin concentration (including the control solution) were administered in a randomized block design in order to control for participant anticipation of inhaling the vapor. The dosimeter was programmed to deliver each