CHEST

Original Research

SIGNS AND SYMPTOMS OF CHEST DISEASES

Concordance and Discriminatory Power of Cough Measurement Devices for Individuals With Parkinson Disease

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Background: **Dysphagia and aspiration pneumonia are two causes of morbidity in Parkinson disease (PD). In PD, impaired airway clearance can lead to penetration of foreign material, resulting in a high prevalence of aspiration pneumonia and death. This study examines three different devices for measurement of peak airflow during voluntary cough in healthy control subjects and those with PD. Two simple and low-cost devices for measuring peak cough airflow were compared with the "gold standard" pneumotachograph.**

Methods: **Thirty-five healthy control subjects and 35 individuals with PD produced voluntary cough at three perceived strengths (weak, moderate, and strong cough) for each of the three devices.**

Results: **A significant difference in mean peak cough airflow was demonstrated for disease ($F[1,56] = 4.0$, $P < .05$) and sex ($F[1,56] = 9.59$, $P < .003$) across devices. The digital and analog meters were comparable to the gold standard demonstrating no significant difference (statistical) by device (digital vs analog) in receiver operating characteristic curve analysis. Both devices were discriminative of the presence of PD.**

Conclusions: **The analog and digital peak airflow meters are suitable alternatives to the gold standard pneumotachograph due to their low cost, portability, ease of use, and high sensitivity relative to normative peak cough airflows. Voluntary cough airflow measures may serve as a noninvasive means of screening for aspiration risk in target populations. Additionally, quantification of cough strength through use of predetermined limens for weak, moderate, and strong cough may assist clinicians in better describing and tracking cough strength as a contributing factor to aspiration risk.**

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Abbreviations: AUROC = area under the receiver operating characteristic curve; HC = healthy control; HY = Hoehn and Yahr; PD = Parkinson disease

Swallow and cough, respectively, serve as preventative and corrective airway processes protecting the lower airways through presumed reconfiguration of integrated neural pathways important for respiratory control. For example, intricate coordination of breathing and swallowing is required to safely transfer a bolus from the oral cavity into the lower digestive tract. Should material be aspirated into the lower airways, a separate series of events also involving cough and swallow will be elicited as an initial attempt to clear the airway. When the coordination of these processes fails, there is increased potential for penetration of foreign material, which can seed the subglottic airways resulting in a high prevalence of aspiration pneumonia.[1] Mortality rates for aspiration pneumonia in those with Parkinson disease (PD) can approach 40%.[2] Aspiration is of particular concern for individuals with neurodegenerative disease processes, where breathing and swallowing are frequently impaired.[3-10] There is a compelling need for strategies to screen and treat weak or inadequate airway protective behaviors in those with PD and others with neurodegenerative disease.

The addition of voluntary peak cough airflow measures to existing swallow-based clinical assessments may improve existing procedures for determining aspiration risk. We seek to facilitate this transition by empirically evaluating a simple, cost-effective means of measuring voluntary peak cough airflow in comparison with the current "gold standard" pneumotachograph. This project intends to reveal a device-driven, cost-effective tool for the noninvasive evaluation of voluntary cough function. Ultimately, this tool, in

combination with swallow-based clinical assessments, may assist in efficiently assessing patients' ability to produce both preventative (swallow) and corrective (voluntary cough) airway protective functions. Additionally, quick quantitative assessment of cough strength using consensus limens for weak, moderate, or strong cough can assist clinicians in the reporting of cough function for the purposes of describing aspiration risk in individuals with PD.

Materials and Methods

Participants

Seventy participants completed all study tasks (34 women, 36 men) of which 35 were healthy control (HC) subjects (24 women, mean age, 67.75 years, SD = 9.4 years; 11 men, mean age, 60.4 years, SD = 16.2 years), and 35 were diagnosed with PD (10 women, mean age, 73.4 years, SD = 4.6 years; 25 men, mean age, 72.0 years, SD = 5.1 years). The Hoehn and Yahr (HY) ratings of participants with PD ranged from 2 to 5 with a mean HY of 3.31 (SD = 0.96). Mean years since diagnosis of PD was 6.8 years (SD = 5.8 years). Participants with PD were considered for inclusion based on the following criteria: (1) diagnosis of PD by a neurologist; (2) between 30 and 80 years of age; (3) nonsmoking or no smoking within the previous 5 years; (4) no history of head and neck cancer, asthma, COPD, or untreated hypertension; (5) sufficient facial muscle strength so as to achieve and maintain adequate lip closure around a circular mouthpiece; (6) cognition within normal limits as determined by the Mini Mental Status Examination; and (7) no neurologic (other than PD) condition that adversely affects respiratory muscle or gas exchange system. All participants with PD were tested while in the on-medication response curve, defined as 1 h postmedication intake. At the time of testing, no participants showed signs of dyskinesia.

Inclusion and exclusion criteria for HC participants were identical to those of participants with PD with the exception of diagnosis of PD. This study was conducted in accordance with the amended Declaration of Helsinki. The University of Florida Institutional Review Board (UFIRB01, project 367-2010) approved the protocol, and written informed consent was obtained from all participants.

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Cough Production

Following informed consent, all participants underwent assessment of voluntary peak cough airflows. Participation in the study required approximately 30 min and involved the production of voluntary coughs at three perceived strengths (weak, moderate, and strong) into three separate sensing devices (an analog peak airflow meter, a digital peak airflow meter, and a pneumotachograph). For each device, the weak, moderate, and strong productions were repeated three times, in a random sequence. Therefore, each participant produced a total of 27 cough samples (three productions of three perceived strengths on each of three devices).

Devices

The analog peak flow meter used in this investigation was the Mini Wright Peak Flow Meter (Mini Wright) featuring a high-visibility scale ranging from 60 to 850 L per minute. The meters used in this investigation were standard range with a larger diameter for use by adults. Per the manufacturer's website, the meter is lightweight, compact, latex free, and able to be sterilized.[11] The analog peak flow meters retail for approximately 30 US dollars per unit.

The digital peak flow meter used in this investigation is also manufactured by Mini Wright. The meter is powered by a lithium coin 3V battery (included and unable to be replaced) and features a range of 60 to 850 L per minute. For all participants, this meter was used in conjunction with a disposable pulmonary function test filter (CBI 1501U small, 30.15 mm outer diameter, 26.40 mm inner diameter) with 99.99% viral and bacterial filtration efficiency (Creative Biotech, Inc). The pneumotachograph used in this investigation consisted of a PowerLab Multi Channel Data Acquisition System used in conjunction with a Spirometer Pod and MLT300L Respiratory Flow Head 300L and disposable pulmonary function test filter with viral and bacteriologic filtration efficiency (all from ADInstruments). Signals were collected and analyzed using LabChart software (ADInstruments). Prior to cough data collection, the integrated pneumotachograph signal was calibrated directly for volume and (via formula) for flow by injecting a known 3-L volume of air through the experimental setup. Flow (F) was then calculated from the slope (rate of change) of the volume (V): $F = dV/dt$.

The production of voluntary coughs for each participant followed a minimum of three cycles of tidal volume breathing, and each cough trial was separated by approximately 1 min of rest to minimize fatigue. Prior to testing, participants were given verbal instruction to assist them in producing cough responses at the desired strengths. This instruction involved first verbally cueing each participant to produce a very soft cough. Productions that were not reflective of a "true cough" (eg, no glottal closure, just exhaled air) were corrected by the investigator through repeat cueing. After demonstrating adequate production of a soft cough, participants were cued to "cough as hard as you can." For moderate cough, participants were cued to produce a cough "right between the soft cough and hard cough." No apparent fatigue was observed in any of the participants during the experiment nor did any participant request to discontinue the trials. The order of the cough productions and device types was computer randomized with the exception of the first three coughs, which participants were always instructed to perform in the following order (so as to mimic the instruction given prior to testing): (1) soft, (2) hard, and (3) medium. No adverse events were reported at the time of the experiment or during the 6-month period following consent of the final participants.[12]

Analysis

The analysis portion of the project was automated using LabChart 7.0 software (ADInstruments) and its associated algorithms,