Journal of Critical Care 33 (2016) 90–94

Contents lists available at ScienceDirect

Journal of Critical Care

journal homepage: www.jccjournal.org

Comparison of cough reflex testing with videoendoscopy in recently extubated intensive care unit patients☆

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ARTICLE INFO

Keywords:
Extubation
Cough reflex
ICU
Dysphagia
Aspiration

ABSTRACT

Purpose: Orotracheal intubation is known to impair cough reflex, but the validity of cough reflex testing (CRT) as a screening tool for silent aspiration in this population is unknown.
Material and methods: One hundred and six participants in a tertiary-level intensive care unit (ICU) underwent CRT and videoendoscopic evaluation of swallowing (VES) within 24 hours of extubation. Cough reflex threshold was established for each participant using nebulized citric acid.
Results: Thirty-nine (37%) participants had an absent cough to CRT. Thirteen (12%) participants aspirated on VES, 9 (69%) without a cough response. Sensitivity of CRT to identify silent aspiration was excellent, but specificity was poor. There was a significant correlation between intubation duration and presence of aspiration on VES (P= .0107). There was no significant correlation between silent aspiration on VES and length of intubation, age, sex, diagnosis at intensive care unit admission, indication for intubation, Acute Physiology and Chronic Health Evaluation III score, morphine equivalent dose, or time of testing postextubation.
Conclusions: Intensive care unit patients are at increased risk of aspiration in the 24 hours following extubation, and an impaired cough reflex is common. However, CRT overidentifies risk of silent aspiration in this population.

1. Introduction

Silent aspiration occurs when oropharyngeal contents contaminate the airway at or below the glottic level without stimulating an overt, behavioral response. Cough reflex testing (CRT) was first described as a screening assessment for identifying an individual's risk of silently aspirating food or fluid in the late 1990s when Addington and colleagues [1] reported a link between absent cough reflex and pneumonia. Others have investigated the validity of CRT as a screening tool for silent aspiration. Miles and colleagues [2] reported a significant association between CRT results and airway response to aspiration on videofluoroscopic swallowing study (VFSS) and videoendoscopy of swallowing (VES) in participants with a range of diagnoses. Sensitivity and specificity were optimized at 69% and 71%, respectively, when compared with results of VES [2]. Wakasugi et al [3] reported sensitivity and specificity of 0.87 and 0.89, respectively, for detection of silent aspiration on VFSS. Sato and colleagues [4] reported a sensitivity and specificity of 0.92 and 0.94, respectively, to detect silent aspiration within participants who aspirated; participants who did not cough within 30 seconds of citric acid administration were considered to have an abnormal reflex.

The phenomenon of postextubation dysphagia and the occurrence of aspiration, both overt and silent, are well documented [5]. In a study by Leder and colleagues [6], 20% of patients admitted to the intensive care unit (ICU) following trauma, who had been intubated for longer than 48 hours, were seen to silently aspirate on endoscopy 24 hours after extubation. There is less evidence of the effect of intubation on the cough reflex. Kallesen and colleagues [7] found that 60% of participants after coronary artery bypass graft surgery had an absent reflexive cough to citric acid when tested within 2 hours of extubation; for 20% of these participants, it was more than 24 hours postextubation before cough reflex returned. However, it is unknown if the prevalence of cough reflex impairment is similar in other patient groups after extubation or if absent cough reflex on CRT is associated with an increased risk of aspiration in the ICU postextubation population.

The primary aim of this study was to determine validity of the CRT for identifying patients at risk of silent aspiration postextubation. The secondary aim was to identify the prevalence of aspiration, both overt and silent, in recently extubated ICU patients.

2. Material and methods

This study was conducted in accordance with the amended Declaration of Helsinki and received appropriate regional ethics approval. All

☆ None of the authors listed above are aware of any conflicts of interest.
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http://dx.doi.org/10.1016/j.jcrc.2016.02.004
0883-9441/

participants provided informed consent for participation in the study, including use of their medical information.

2.1. Subjects

Patients older than 18 years who were admitted to the ICU and required invasive ventilation were eligible for participation in this study. Patients who were receiving palliative care only were excluded. Because completion of the VES required ingestion of fluid, those who were strictly nil by mouth for surgical or gastrointestinal reasons or who were considered unsafe for oral intake because of a reduced Glasgow Coma Scale (GCS) score (patients scoring 12 or less) were also excluded. The study size was calculated to give 80% power to detect a reduction of sensitivity from 90% to 60% at the .05 level of significance [8]. Enrolment occurred between May and December 2014.

2.2. Study design

Participants were enrolled after extubation. If a participant's GCS was less than 15, both the participant's assent and agreement of the next of kin were required for enrolment. CRT and VES were performed within 24 hours of extubation by a single researcher. VES always followed CRT within 1 hour and was interpreted by a speech-language pathologist blinded to CRT results. This ensured that the VES result could not influence CRT interpretation. In addition to performing CRT and VES, the researcher gathered demographic and treatment details, including admitting diagnosis, reason for intubation, length of intubation, Acute Physiology and Chronic Health Evaluation (APACHE) score, and morphine equivalent dose (mg/kg) in the 12 and 24 hours preceding testing. Where opiates other than morphine were administered, the morphine equivalent dose was calculated assuming that 10 μg fentanyl was equivalent to 1 mg morphine. The total morphine equivalent dose administered from time of induction to CRT was divided first by participant weight in kilograms then by the number of hours in this period to determine the administered mean morphine in milligrams per kilogram per hour (mg/[kg h]).

2.3. Cough reflex testing

Citric acid concentrations were selected based on previous research by Miles and colleagues [2] that found that 0.4 mol/L had optimal sensitivity and specificity for identifying silent aspiration when using a natural cough method. For this study, the researchers chose a suppressed cough method, instructing participants to try to suppress a cough to guard against placebo cough and because it may represent a more accurate reflection of the true reflexive cough [9]. Also, the researcher's experience in performing CRT with cardiothoracic patients in ICU indicated that these patients naturally suppress cough because of the pain associated with coughing. Requiring all participants to perform a suppressed cough ensured consistency of methods. Normative data indicate that individuals' suppressed cough threshold is significantly higher than their natural cough threshold [10], so concentrations of 0.4, 0.6, and 0.8 mL/L of 0.9% sodium chloride were selected. The citric acid solution was prepared as per the recommendations of Falconer and colleagues [11] in 5-mL syringes by Optimus Healthcare Ltd and was presented using a PulmoMate Compressor/Nebulizer (Model 4650I; DeVilbiss Healthcare LLC, Somerset, PA) with a predetermined free-flow output of 8 L/min and a restricted flow output of 6.6 L/min via a face mask.

The participant was seated upright to at least 60°. Supplemental oxygen was removed during delivery of aerosol. The lowest concentration of citric acid, 0.4 mol/L, was presented first, followed by 0.6 and 0.8 mol/L until the participant coughed. Nebulized 0.9% saline was interspersed between citric acid doses [12]. Citric acid was delivered for 15 seconds, and participants were instructed to "breathe normally and try not to cough." Supplemental oxygen was returned between tests to avoid hypoxemia. Each concentration was presented up to 3 times with a minimum of 30 seconds between each presentation to prevent tachyphylaxis [12]. In this study, *cough* is defined as a "forced expulsive maneuver or maneuvers against a closed glottis that are associated with a characteristic sound or sounds" as recommended in the European Respiratory Society guidelines on the assessment of cough [12]. The cough reflex was considered present if the participant produced 2 or more audible successive coughs on 2 presentations of a single concentration. Cough reflex was classified as strong if the researcher judged the cough to be sufficient to clear aspirated material or weak if judged insufficient. If the participant coughed on 2 trials of 0.9% saline, the participant's response was considered unreliable, and the participant was excluded. Increasing concentrations were presented until the cough reflex threshold was identified or judged absent.

2.4. Videoendoscopic evaluation of swallowing

Videoendoscopic evaluation of swallowing was performed at the participant's bedside using an Olympus ENf-V2 Ultra Slim Rhinolarnygo Videoscope (Olympus Corporation, Shinjuku, Tokyo, Japan). Images were recorded onto an Olympus IMH-10 image capture device. Participants did not receive topical anesthesia. The scope was passed transnasally, and the tip was positioned in the pharynx, allowing for a clear view of pharyngeal and laryngeal structures. Each participant was asked to swallow 5 single sips of blue-dyed milk (or juice if unable to drink milk) via straw followed by approximately 150 mL via consecutive swallows. If the participants demonstrated aspiration on single sips, they were not asked to take consecutive sips. The videos obtained from all studies were recorded on an external computer hard drive and later evaluated using the Penetration Aspiration Scale (PAS) [13]. Presence or absence of reflexive cough was also recorded.

2.5. Statistical analysis

Statistical analyses were completed using SPSSv22 software (SPPS, Chicago, IL). Sensitivity and specificity tables were created using χ^2 tests with Pearson coefficient or, when expected count of any group was less than 10, Fisher exact test. Analyses was completed with weak responses grouped with strong and with weak grouped with absent. Generalized linear mixed-effects analysis was completed to examine the data for correlations between the independent variables and both the presence or absence of cough reflex to CRT and the presence or absence of aspiration on VES. Descriptive statistics are presented as means with standard deviation or medians with interquartile range (IQR) depending on the data distribution. Categorical data are presented as raw numbers and percentage. In cases where data were missing, no assumptions were made about missing data.

3. Results

One hundred and twelve participants were enrolled in the study. Five participants were excluded because they could not participate owing to agitation or reduced GCS, and one participant declined VES. Therefore, 106 participants underwent both CRT and VES. Participant characteristics are displayed in Table 1. Testing was initiated at a median of 18 hours postextubation (IQR = 9-22).

4. Test results

Fifty-four percent of participants had an absent cough reflex to CRT at 0.4 mol/L (n = 57), 46% at 0.6 mol/L (n = 49), and 37% at 0.8 mol/L (n = 39) nebulized citric acid. Correlation between duration to testing postextubation and the presence or absence of a cough reflex was not significant (P= .07). Age, sex, length of intubation, ethnicity, diagnosis, reason for intubation, APACHE III score, and morphine equivalent dose