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Recovery of cough after extubation after coronary artery bypass grafting: A prospective study☆,☆☆

Molly Kallesen, MSc [a,b,*], Alex Psirides, MBBS, BSc (Hons), FCICM [b], Maggie-Lee Huckabee, PhD [a]

[a] The University of Canterbury Rose Centre for Stroke Recovery and Research, Leinster Chambers, Christchurch 8014, New Zealand
[b] Capital and Coast District Health Board, Wellington South 6242, New Zealand

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ABSTRACT

Purpose: This study aims to evaluate the effect of intubation for coronary artery bypass grafting (CABG) on the cough reflex, an important airway protection mechanism.
Materials: Eighty-six participants (70 males) underwent cough reflex texting (CRT) before intubation for CABG to establish baseline threshold for reflexive cough. Cough reflex texting was repeated within 2 hours of extubation and every morning and evening thereafter until the participant coughed at baseline level, withdrew, or was discharged from hospital.
Results: Sixty percent of participants had an absent cough reflex at CRT2 (x = 70 minutes). Participants varied in time to recovery of cough reflex. By CRT6, only 3 remaining participants persisted with an absent cough. Age, sex, or length of intubation had no significant impact on the time to recovery of cough reflex ($P > .3$).
Conclusions: Absent cough reflex persists after CABG and may impact patients' ability to clear their airway in the event of aspiration. These results could contribute to better understanding postextubation dysphagia. More research is needed to determine if cough reflex is affected in the wider intensive care unit population postextubation and if CRT is a valid tool for detecting silent aspiration in this population.

1. Introduction

Dysphagia and aspiration pneumonia are common occurrences in the intensive care unit (ICU) population after a period of tracheal intubation. The prevalence of aspiration in a general ICU population is reported to range from 27% to 56% of patients [1-3].

Silent aspiration is said to occur when oropharyngeal contents contaminate at or below glottic level without stimulating an overt, behavioral response. This is of particular concern because it cannot be identified by clinical assessment and is a major risk factor in the development of lower respiratory tract infection [3]. Silent aspiration prevalence has been reported to be as high as 25% [1] within 24 hours of extubation among ICU patients who have been intubated for more than 48 hours.

Tracheal intubation is followed by a variable period of disturbed airway reflexes [4,5], which may, in turn, contribute to the risk of silent aspiration and subsequent respiratory complications. The relationship between an abnormal cough reflex and aspiration risk is established. Cough reflex testing (CRT) has been used in research and clinical practice as a tool for assessing laryngeal sensitivity and inferring an individual's ability to protect their airway [6-8]. Miles et al [9] demonstrated that patients with an absent cough response to 0.8 mol/L nebulized citric acid had an 8-fold increased risk of aspiration on videofluoroscopic swallowing evaluation. Although there are some limited data demonstrating abnormal airway reflexes immediately postextubation, little is known about the duration of these effects into the clinical recovery phase. For many, this will be a critical period, where mobilization and resumption of oral intake are initiated.

Patients undergoing cardiac surgery are routinely admitted to the ICU postoperatively and, in most cases, remain intubated for the first part of their ICU stay. As with other ICU patients, the cardiac population is at risk for developing postoperative dysphagia [10-12]. Hogue et al [12] performed videofluoroscopic swallow studies on all patients who demonstrated dysphagia or coughed when drinking after cardiac surgery requiring cardiopulmonary bypass. Of the participants who underwent videofluoroscopic swallow studies, 90% demonstrated aspiration, 22% of these without stimulating a cough response. By examining only those with an overt swallowing problem, it is likely that their method of participant selection would have missed a number of patients who were silently aspirating.

The aim of this study was to document the prevalence of impaired cough reflex after tracheal intubation in patients undergoing elective

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☆☆ This study is included in the Australian New Zealand Clinical Trials Registry, number ACTRN12614000917639, and can be found at http://www.ANZCTR.org.au/ACTRN12614000917639.aspx.

* Corresponding author at: The University of Canterbury Rose Centre for Stroke Recovery and Research, Leinster Chambers, Level 1, 249 Papanui Road, Christchurch 8014, New Zealand. Tel.: +64 48062345.
E-mail addresses: molly.kallesen@ccdhb.org.nz (M. Kallesen), alex.psirides@ccdhb.org.nz (A. Psirides), maggie-lee.huckabee@canterbury.ac.nz (M.-L. Huckabee).

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coronary artery bypass grafting (CABG) and to examine the time course of recovery of baseline cough in the hours and days after extubation.

2. Materials and methods

This study was conducted in accordance with the amended Declaration of Helsinki and received appropriate ethics approval. All participants provided written informed consent for participation in the study, including use of their medical information.

2.1. Subjects

Patients older than 18 years and scheduled for elective CABG at the study hospital were eligible. Patients having valve surgery alone or valve surgery with CABG were excluded. All patients were placed on cardiopulmonary bypass for their surgery. The study size was chosen to give 90% power to estimate the proportion of patients whose cough reflex had diminished with a measurement error of $\pm 10\%$ (Stata/IC 11.2; StataCorp LP, College Station, TX). Eighty-six participants (70 males) were enrolled between February and September 2012. The mean age of participants was 65 years of age (39-79 years). Participants were excluded if they had a history of dysphagia, head and neck cancer, or neurologic disease. All but 3 participants had an intraoperative transesophageal echocardiograph probe placed, and none required an intraaortic balloon pump, both which have been linked with postoperative dysphagia in patients undergoing cardiac operations [12,13]. All participants received opioids as part of their initial anesthetic and for analgesia during the follow-up period.

2.2. Study design

The procedure is represented in Fig. 1. Each participant was enrolled before surgery. At the time of enrollment, CRT, as described below, was performed to establish each participant's baseline threshold for reflexive cough (CRT1). Two participants were excluded because they did not cough at any concentration; therefore, postextubation reduction in cough could not be assessed.

When each participant was extubated after surgery, the ICU nurse notified the researcher who then performed the first follow-up assessment (CRT2) within 2 hours of extubation. Each participant who failed CRT2 was further evaluated each morning between 7 AM and 9 AM and each evening between 7 PM and 10 PM. Testing was continued until each participant's cough was judged to be at their baseline (CRT1) level, they were discharged from hospital, they withdrew, or they died. Follow-up testing was performed in ICU and in the cardiothoracic unit. In addition to CRT results and demographic information, anesthetic and surgical details (endotracheal tube size; airway intubation grade; time of intubation; name of surgeon, anesthetist, perfusionist; cardiopulmonary bypass time; aortic cross-clamp time; transesophageal echocardiograph probe use; and opioid type and dose) and information regarding ongoing treatment (time of extubation, ICU discharge date, hospital discharge date, discharge destination, glomerular filtration rate, and Acute Physiology and Chronic Health Evaluation III score) were gathered from the medical record.

2.3. Cough reflex testing

Five-milliliter syringes of sterile citric acid diluted in 0.9% sodium chloride were prepared in 3 concentrations: 0.4, 0.8, and 1.2 mol/L. These concentrations were chosen based on normative data, which indicates that 95.5% of normal participants triggered suppressed cough at or below 1.2 mol/L while the mean for triggered suppressed cough for elders was 1.03 mol/L [14]. Citric acid solution was presented using a PulmoMate Compressor/Nebuliser (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.

The participant was seated upright to at least 60°. The lowest concentration of citric acid (0.4 mol/L) was presented first, followed by 0.8 and 1.2 mol/L as needed. Citric acid was delivered for 15 seconds, and patients were instructed to "breathe normally and try not to cough." A suppressed cough method was chosen to guard against placebo cough and because it may represent a more accurate reflection of the true reflexive cough [14]. In addition, patients are very reluctant to cough after cardiothoracic surgery and instinctively suppress cough, so use of a suppressed cough method ensured consistency in preintubation and postintubation testing. Each concentration was presented up to 3 times with a minimum of 30 seconds between each presentation to prevent tachyphylaxis [15]. In this study, we define cough as a "forced expulsive maneuver or maneuvers against a closed glottis that are associated with a characteristic sound or sounds," which is consistent with European Respiratory Society recommendations [15]. The cough reflex was considered present if the participant produced 2 or more audible successive coughs on 2 presentations of a single concentration. After a positive response, a trial of normal saline was presented to ensure the cough response was genuine. If the participant coughed on 2 trials of saline, the cough response was considered abnormal and the participant was excluded. Increasing concentrations were presented until the cough reflex threshold was identified or judged absent. During follow-up testing, the participant's baseline threshold was the lowest concentration of citric acid used.

2.4. Opioids

Opioids are known to suppress cough [16]. All patients were sedated postoperatively with propofol and only extubated once sedation had been ceased and they awoke. All received opioids as part of their anesthesia and for postoperative analgesia. The only opioids administered were either morphine or fentanyl; the latter was used in patients with preexisting or postoperative renal impairment. No other agents with known antitussive properties (eg, lidocaine) were used with patients in the postextubation period.

The morphine equivalent dose was calculated for each participant using 10 μg fentanyl equals 1 mg morphine. The total morphine equivalent dose administered from time of induction to final CRT was divided first by patient weight in kilograms then by the number of hours in this period to determine the administered mean morphine in milligrams per kilogram per hour. Further analysis of opioid dose was completed on data from CRT2. Morphine equivalent dose in milligrams per kilogram per hour was again calculated for each participant, capturing only

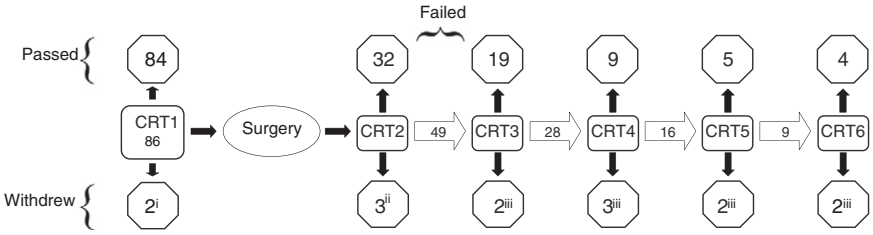

Fig. 1. Study design with numbers of participants at each testing period.