Journal of Critical Care 45 (2018) 1–6

Contents lists available at ScienceDirect

Journal of Critical Care

journal homepage: www.jccjournal.org

Bedside screen for oral cavity structure, salivary flow, and vocal production over the 14 days following endotracheal extubation

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ARTICLE INFO

Available online xxxx

Keywords:
Endotracheal intubation
Dysphonia
Temporomandibular joint
Saliva
Oral motor function

ABSTRACT

Purpose: To describe the sequelae of oral endotracheal intubation by evaluating prevalence rates of structural injury, hyposalivation, and impaired vocal production over 14 days following extubation.

Materials and methods: Consecutive adults (≥20 years, $N = 114$) with prolonged (≥48 h) endotracheal intubation were enrolled from medical intensive care units at a university hospital. Participants were assessed by trained nurses at 2, 7, and 14 days after extubation, using a standardized bedside screening protocol.

Results: Within 48-hour postextubation, structural injuries were common, with 51% having restricted mouth opening. Unstimulated salivary flow was reduced in 43%. For vocal production, 51% had inadequate breathing support for phonation, dysphonia was common (94% had hoarseness and 36% showed reduced efficiency of vocal fold closure), and >40% had impaired articulatory precision. By 14 days postextubation, recovery was noted in most conditions, but reduced efficiency of vocal fold closure persisted. Restricted mouth opening (39%) and reduced salivary flow (34%) remained highly prevalent.

Conclusions: After extubation, restricted mouth opening, reduced salivary flow, and dysphonia were common and prolonged in recovery. Reduced efficiency of vocal cord closure persisted at 14 days postextubation. The extent and duration of these sequelae remind clinicians to screen for them up to 2 weeks after extubation.

1. Introduction

Oral endotracheal intubation sustains life, but can cause direct trauma and injury to anatomical structures of the oral cavity, pharynx, larynx, and temporomandibular joint (TMJ), affecting functions of salivary flow and vocal production [1-4]. For patients who have survived a critical illness and had their endotracheal tube removed, structural injury (i.e., oral cavity ulceration, deviation/clicking at mouth opening, or restricted mouth opening), hyposalivation (thick saliva or reduced salivary flow), and impaired vocal production (inadequate breathing support for phonation, dysphonia, impaired articulatory precision) not only cause discomfort, but also affect their ability to resume oral intake and communicate effectively [5-8].

Evaluating the sequelae of prolonged endotracheal intubation on oral motor performance is important. Following extubation, most patients complain of mild to moderate symptoms including oral ulcers, restricted jaw movement, dry mouth, sore throat, hoarseness, inability to speak clearly, and difficulties chewing or swallowing [1,3,6,8,9]. These sequelae have many consequences. For example, the oral cavity has a rich somatosensory innervation; thus, ulceration or lesions in the tongue and parts of the oral cavity may reduce proprioception and compromise oral sensorimotor control in eating and speaking [10]. TMJ dysfunction manifested by clicking noises during mouth opening or restricted mouth opening can also cause difficulty in eating or speaking [11]. Reduced salivary flow causes a clinically oral imbalance manifested by altered taste perception, increased caries incidence, and difficulties with chewing, swallowing, and vocal production because of insufficient wetting and decreased lubrication of the oral cavity/pharynx/larynx and food bolus [12]. Impaired vocal production in patients without neurological diseases may reflect laryngeal pathology, insufficient respiratory drive, and/or motor inability of the lips and tongue (structures involved

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https://doi.org/10.1016/j.jcrc.2017.11.035
0883-9441/

in speech), compromising oral intake and communication [13]. Moreover, structural injury in the oral cavity and TMJ, hyposalivation, and impaired vocal production may be modifiable by interventions such as oral care, oral motor exercise, systematic hydration/saliva substitutes, voice rehabilitation, or referrals to appropriate specialists [14-16].

However, previous studies on the sequelae of endotracheal intubation have predominantly focused on using endoscopy diagnostic tests to define structural injury, including nerve damage [17] and laryngeal pathology [18-20]. Although this approach is scientifically sound, it is invasive and expensive, and the findings are limited by patients often feeling that their function has not yet returned, despite unremarkable endoscopic findings or vice versa. An alternative approach could be to establish a performance-based, bedside screening protocol that assesses whether the sequelae of endotracheal intubation are resolved from a patient perspective instead of a pathological one. This bedside screening could then serve as part of patients' routine evaluation to identify those who need interventions or referrals to ear-nose-throat (ENT), dental, or rehabilitation services. Thus, this pilot study was undertaken using a bedside screening protocol that could be part of a routine evaluation to describe the sequelae of endotracheal intubation in terms of oral motor performance. Specifically, we assessed prevalence rates of structural injury, hyposalivation, and impaired vocal production up to 14 days from extubation in 114 medical intensive care unit (ICU) patients intubated for at least 48 h and with no preexisting swallowing dysfunction or neuromuscular disease that might affect vocal production.

2. Materials and methods

2.1. Study design, sample, and setting

This prospective pilot study was conducted at a tertiary medical center in Taiwan. As part of a cohort study [8], participants were recruited from consecutive adult patients (≥20 years old, the legal age to consent) admitted to the medical center's medical ICUs from April 2013 to December 2014 and who had received emergency oral endotracheal intubation for at least 48 h. Participants were evaluated at 2, 7, and 14 days after extubation. Patients were excluded if they 1) had a history of neurologic disease (i.e., stroke, parkinsonism, or brain trauma) or head and neck deformities that might affect their vocal production, 2) had a preexisting swallowing difficulty, 3) were delirious or unable to respond to questions, 4) received tracheostomy, or 5) were isolated for infectious disease.

The standardized screening protocol included measures that could feasibly be part of a routine history and physical examination (see Appendix I). We note that a comprehensive evaluation of speech function was not a study focus. Instead, we aimed to screen vocal production and verify individuals' speech motor skills (i.e., a lip seal and tongue agility) given that these would likely be affected by prolonged endotracheal intubation. The study was approved by the Institutional Research Ethics Board, and all patients signed written informed consent to participate in the study.

2.2. Data collection

Data were collected by two research nurses using a standardized screening protocol (Appendix I) on structural injury, hyposalivation, and impaired vocal production. The nurses had at least 5 years of ICU experience and were specially trained for the screening procedure by a speech therapist and ENT and rehabilitation physicians. Since no speech therapist was available in our ICU settings, we enhanced data reliability by having these nurses evaluate patients simultaneously until they agreed on each code for all participants. Patients were evaluated three times after extubation (within 48 h, and 7 and 14 days), as described below.

The oral cavity was evaluated using pen lights. The appearance of the lips, tongue, and mucosal membrane of the palate, uvula, and pillar was examined for ulceration (yes/no). Although our screening protocol might not be sufficient as a full evaluation, TMJ dysfunction was assessed by deviation or clicking during mouth opening (yes/no) or restricted mouth opening (yes/no), defined as the maximal mouth opening distance between the incisal edges of the upper and lower central incisors ≤ 35 mm [22]. This opening distance (mm) was measured with a metallic caliper between the incisal edges of the upper and lower central incisors.

Salivary characteristics (thick saliva or dry oral mucosa; yes/no) were assessed, and unstimulated, whole mouth salivary flow was evaluated using the oral Schirmer test. With participants sitting upright, nurses held a standardized 1-cm wide and 17-cm long Schirmer tear test strip vertically, with the rounded end of the strip placed at the floor of their mouth. At the end of 5 min, a wetting length ≤ 30 mm indicated hyposalivation with a sensitivity of 68% and specificity of 63% to predict salivary gland hypofunction [23].

For vocal production, inadequate breathing support for phonation (yes/no) was evaluated by asking participants to count from 1 to 20. Participants who required more than four breaths to count were considered abnormal [9,24]. Dysphonia was evaluated by hoarseness/phonation difficulty (yes/no) and reduced efficiency of vocal cord closure (yes/no; estimated by an s/z ratio > 1.4). During verbal conversation, nurses rated participants' voices as "normal," or "hoarse/phonation difficulty." The nurses then asked participants to take a deep breath and to sustain the sound /s/ for as long as possible on one exhalation and recorded the maximum phonation of /s/ in seconds. This step was repeated to record the maximum phonation of /z/ in seconds [25]. Using an s/z ratio > 1.4 as the cutoff, impaired vocal cord closure was diagnosed with 100% sensitivity and 93% specificity in 24 h after endotracheal intubation [26]. Articulatory precision was screened by lip seal and lingual diadochokinesis (DDK) or agility [27-28]. Participants were asked to say/p/-/p/ clearly 10 times; such a task obliges participants to make rapidly alternating labial movements and thus evaluates bilabial stops [27]. Poor lip seal (yes/no) was defined as "inability to visually or auditorily represent sound," "very poor lip seal and not auditorily represented," or "lip seal observed but auditorily weak." The lingual DDK measures how accurately an individual can repeat a series of rapid, alternating phonemes. As suggested by the Frenchay dysarthria assessment, participants were asked to say /k/-/a/-/l/-/a/ 10 times quickly [27]. Other sets of sounds such as /b/-/d/-/g/ were not used to evaluate DDK because those sounds are not used in Chinese and are difficult for Chinese speakers to pronounce. Poor lingual DDK (yes/no) was defined as "no change in tongue position," "tongue changes in position but unidentified sounds," or "not all are well articulated" [28].

Data on participants' demographics (age, gender, education [years], current smoker) and medical characteristics (admission diagnosis, comorbidities, illness severity, admission body mass index, medication use, endotracheal tube size, duration of intubation [days], oxygen supplement, frequent airway suction, indwelling nasogastric tube) were obtained from the medical record. Comorbidities were based on the Charlson comorbidity index, with higher scores indicating greater mortality risk [29]. Illness severity was based on Acute Physiology and Chronic Health Evaluation II (APACHE II) scores, with higher scores corresponding to more severe disease [30].

2.3. Statistical analyses

SPSS (version 20) was used for all analyses. Participants' demographic and clinical characteristics were described as percentages, median or mean ± interquartile range or standard deviation. Prevalence rates of structural injury, hyposalivation, and impaired vocal production over three time points were compared and tabulated. Given the exploratory nature of this pilot study, we did not perform correlation analyses