MUCOSAL WAVES ON THE VOCAL FOLDS: CONCEPTUALIZATION BASED ON VIDEOKYMOGRAPHY

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Abstract: **Mucosal waves have been considered of crucial importance for healthy vocal fold vibration, but their appearance and variability have been described only vaguely so far. We studied the appearance of the mucosal waves using videokymography. The mucosal wave was divided in two components: 1) the vertical phase differences between the lower and upper margins of the vocal folds, which are reflected in sharpness of the lateral peaks in kymograms and 2) the waves propagating laterally over the vocal fold surface which can be recognized as lateral movements on the vocal fold surface occurring during medial movement of the glottal edge. Different features of the laterally traveling mucosal waves were recognized. The suggested new classification of the mucosal wave properties opens new possibilities for more sensitive monitoring of the state of the vocal fold tissues in basic voice research and clinical practice.**

Keywords : **Mucosal waves, videokymography, high-speed videolaryngoscopy, vocal fold vibration**

I. INTRODUCTION

Mucosal waves on the vocal folds have been considered of crucial importance for healthy vocal fold vibration. Their presence (absence) reflects on the pliability of the vocal fold mucosa. Mucosal waves are one of the basic laryngeal features evaluated routinely by clinicians using strobolaryngoscopy and used for diagnosis of voice disorders [1]. The waves are known to travel upwards along the medial vocal fold surface and then continue laterally over the upper surface of the vocal folds. Their appearance and variability has been described only vaguely so far, however. The purpose of the present study was to determine the basic features of the mucosal waves in order to allow their better specification and more sensitive evaluation using videokymography.

II. METHODS

More than 7,000 VKG examinations of patients with various types of voice disorders were performed and recorded at the Center for Communication Disorders, Medical Healthcom, Ltd, in Prague from 1996 to 2006. The details of the equipment were described elsewhere [2,3]. The VKG examinations were always preceded by strobovideolaryngoscopy. The subjects' VKG examinations were usually around 1 to 5 minutes in duration and contained approximately 3,000 to 15,000 VKG images, ie, consecutive video fields of 18.4-ms duration. Of the 7,000 patient examinations, only about 20% were processed due to time constraints.

The processing involved field-by-field viewing of the videotape recordings and a search for images with good focus, illumination, and contrast that showed clear vibration patterns at the locations of interest on the vocal folds. These images were digitized with the video board Miro PCTV. From these, 1 or more VKG images were selected by the examiner as the most representative for the subject and were then combined (with Corel Photo Paint software) with corresponding laryngoscopic and laryngostroboscopic images into a final set of images for the patient record [2-4].

For the purposes of the present study, 100 VKG images of sustained phonations from 45 subjects were retrospectively selected from these patient records. The images were selected so that they covered the widest possible spectrum of vocal fold behavior. The images were compared among themselves, and the differences in the appearance of the mucosal waves were analyzed visually.

III. RESULTS

Two components of the mucosal waves were distinguished: 1) the vertical phase differences between the lower and upper margins of the vocal folds, and 2) the continuing waves propagating laterally over the vocal fold surface. The vertical phase differences were found encoded in the videokymographic images in the

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sharpness of the lateral peaks of the vocal-fold waveform contour. The laterally traveling mucosal waves were defined as lateral movements on the vocal fold surface occurring during medial movement of the glottal edge. Based on this new definition, we found four basic features which distinguished various types of laterally traveling mucosal waves: a) lateral extent, b) enhancement/light reflection, c) spatial separation from the vocal fold margin and d) delay in appearance after vocal fold peak displacement. These four features are considered to reflect different mucosal and geometrical properties of the vocal folds.

IV. Discussion

The two components of the mucosal waves reflect, in principle, two different events. Whereas the mucosal movements on the medial surface and the corresponding vertical phase differences are actively driven by the glottal airflow, the laterally traveling waves on the upper vocal fold surface are passive continuations of the vertically traveling mucosal waves. The sharpness of the lateral peaks theoretically reflects pliability of the medial vocal fold surface. The sharper the lateral peaks, the larger the vertical phase differences, and the more pliable the medial vocal fold surface [5,6].

The new definition was found useful for recognizing the laterally traveling mucosal waves and distinguishing them from other events and artifacts on the vocal folds. The laterally traveling mucosal waves reveal on the pliability of the upper vocal fold surface. Theoretically, the larger the lateral extent of the wave, the more pliable the mucosa of the upper surface is [1]. Mucosal wave enhancement by a specular light reflection indicates horizontality of the upper vocal fold surface; separation of the mucosal wave from the margin suggests an enlarged amount of incompressible material in the mucosa (such as edema-fluids); and the appearance delay suggests that the upper surface of the vocal folds is extensively bulged (e.g., from excessive activity of the external part of thyroarytenoid (TA) muscle or due to structural abnormalities). The suggested new classification of the mucosal wave properties opens new possibilities for more sensitive monitoring of the state of the vocal fold tissues in basic voice research and clinical practice.

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