**MACRO**JOURNALS

The Journal of **Macro**Trends in
Health and Medicine

# Videokymography (VKG) in Laryngologic Practice

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## Abstract

*Videokymography is a clinician-friendly version of a high-speed videolaryngoscopic system. It explores a special video camera, which delivers simultaneously two types of images: a) standard laryngoscopic view showing laryngeal structures and b) kymographic view showing vibratory behaviour of these laryngeal structures at a specific selected location along a horizontal line (with the high-speed rate of 7200 line images per second). The kymographic images reveal numerous vibratory features of the vocal folds which allow recognizing in which way the vocal fold functioning is impaired. This allows better understanding of the nature of the voice disorder and a more detailed diagnosis. Here we provide with clinical examples in which the method was found useful in establishing the diagnosis. VKG is helpful particularly in the cases when the vocal fold structure appears rather normal but the voice is impaired.*

Keywords: *Videokymography, Laryngologic Practice*

**Acknowledgment: The work has been supported by the Technology Agency of the Czech Republic project no. TA04010877.**

### 1.Introduction:

Videokymography (VKG), developed originally in 1996, allows displaying patterns of vocal fold vibrations which cannot be properly visualized using stroboscopy (such as irregularities and instabilities, including hoarseness and register transitions) [1;2]. VKG explores images from a single selected line recorded with a high-speed rate (currently 7200 line images per second) [3]. The VKG examination line can be placed at any location of the vocal folds. The line images are put one by one after each other and together form a new „kymographic“ image (shortly „kymogram“) which displays the behaviour of the vocal folds at the specific selected location [1;2].

Modern videokymography explores a special video camera (i.e., videokymographic camera or videokymograph) providing the kymographic images simultaneously, side by side, with the standard laryngoscopic images of the vocal folds [3] (Fig.1). The kymographic images are

displayed immediately during the examination. The immediate availability of the images makes the VKG method suitable for use in busy clinical practice and also distinguishes VKG from other high-speed videoendoscopic (HSV) systems, which can visualize or process the images only after the recording has taken place [4-6].

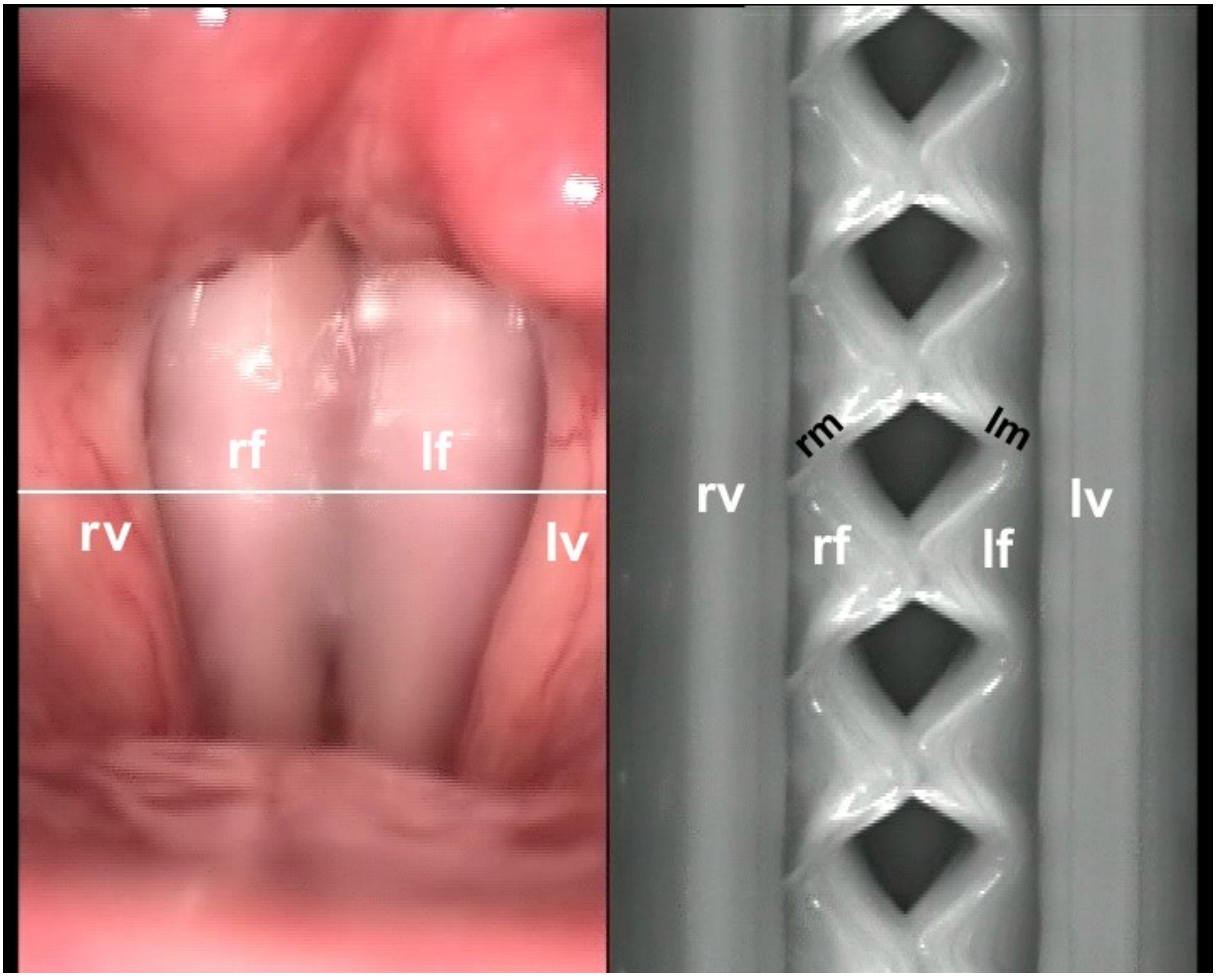


*Figure 1: Normal VKG - The standard laryngoscopic (left) and VKG (right) images. The VKG image shows the normal behaviour of the vocal folds in time at the location marked by the line in the standard image. The examined subject was a 43-year-old male without voice problems. rf/lf – right/left vocal fold, rv/lv – right/left ventricular fold, rm/lm – right/left laterally travelling mucosal wave.*

In contrast to classical laryngoscopy, which aims at observing and evaluating the ***structural appearance*** of the vocal folds and of the laryngeal structures, kymography aims at observing and evaluating the ***vibratory function*** of the vocal folds and of the surrounding tissues. In this sense, the method aims at diagnosing the vibrational problems rather than structural problems of the laryngeal tissues. Since voice is produced through vibration of laryngeal tissues it provides a more detailed insight into the mechanism of voice disorders. The method is especially useful

for discovering vibrational problems in functional dysphonias where the vocal folds do not show any obvious structural abnormality but the voice is impaired in some way. The discovered vibration problems are important to relate to tissue pathology.

## 2. Material and Methods

### 2.1. VKG Equipment And Examination Procedure

The basic equipment for videokymographic examination consists of *1) special videokymographic camera*, *2) laryngeal endoscope*, *3) continuous light source of high intensity* (300 W xenon light is preferable), *4) standard video-capturing system* (computer or a video recorder), *5) video monitor*, and *6) microphone* for capturing the voice signal [7]. Generally, the examination procedure in videokymography is similar to the videolaryngostroboscopic procedure [7].

### 2.2. Evaluation of VKG recordings

Videokymography allows visalizing different types of vibrational characteristics of the vocal folds [2;8]. The following selected characteristics have most often been evaluated in clinical practice:

- presence or absence of oscillations
- regularity of oscillations
- symetry of oscillations
- duration of closure within the cycle
- laterally travelling mucosal waves
- shape (sharpness or roundedness) of lateral peaks
- shape (sharpness or roundedness) of medial peak

The vocal fold vibrations vary when changing pitch, loudness as well as vocal register so care should be taken to take these factors into account [9-11]. Also, the vibratory patterns differ along glottal length [12-14]. Typically, the VKG images are obtained from the place of maximum vibration amplitude (around the middle of glottal length) and from the sites of pathology.

Among the clinically most serious VKG findings in voice disorders are:

*Completely absent vibration of the vocal fold* – a very serious finding, which can result from a tumor, scar or excessive vocal fold stiffness (see the example in Fig.2).

*Reduced vibration amplitude of the vocal fold* – could be observed mainly when the vocal fold is stiff.

*Decreased sharpness of lateral peaks* (rounded lateral peaks of oscillations) – indicates reduced vertical phase differences of the vocal fold, which may result from excessively stiff mucosa on its medial surface.

*Absent or reduced mucosal waves on the upper vocal fold surface*– indicate that the mucosa is excessively stiff on the upper vocal fold surface.

*Sharpened medial peaks* – indicate thinned edge of the vocal fold. It is observable when glottal closure is absent. This can be beginning of the mucosal atrophy of the vocal fold.

## 3. Results

### Clinical Examples:

3.1. Case 1:

63-years old male patient suffering from dysphonia which arose after a cold and lasted for four months. He was a smoker (20 cigarets daily) treated for hypertonicity. The original diagnosis was chronic laryngitis and laryngo-pharyngeal reflux disease.

*VKG examination* revealed complete absence of vibration of the left vocal fold (Figure 2, arrow). This raised a suspicion of tumorous infiltration of the left vocal fold. The patient underwent direct laryngoscopy and histological exam, which revealed squamous cell carcinoma.

*Therapy:* cordectomy l. sin.

*Prognosis:* patient comes for regular check-ups, currently 4th year without problems.

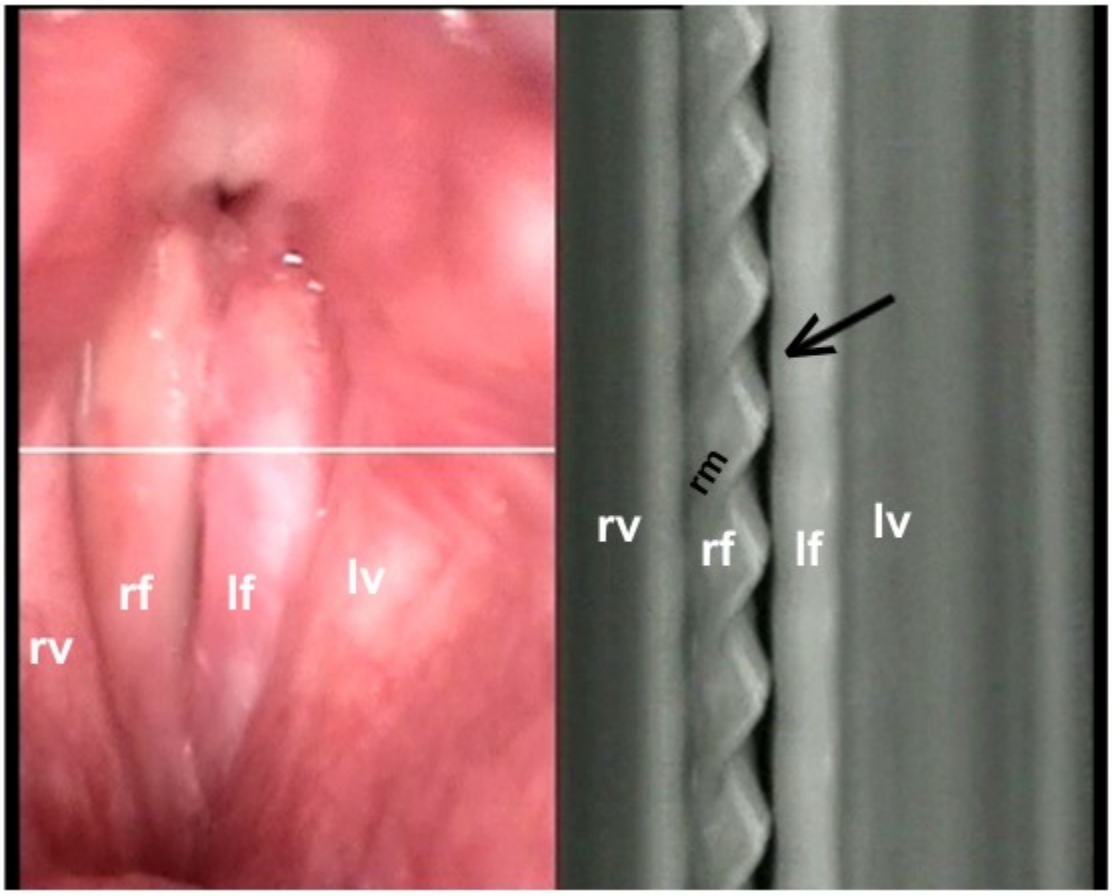


*Figure 2: VKG examination images of a patient with left vocal fold carcinoma (case 1). The left vocal fold shows complete absence of vibrations (arrow), while the right vocal fold shows normal vibratory behaviour. Total time displayed in the VKG image: 40 ms (from top to bottom). rf/lf – right/left vocal fold, rv/lv – right/left ventricular fold, rm – right laterally travelling mucosal wave.*

3.2. Case 2:

29-years old female, operatic singer suffering from dysphonia for two weeks, with difficulties especially when singing high tones. She was very stressed before the show opening night.

Insert Figure 3

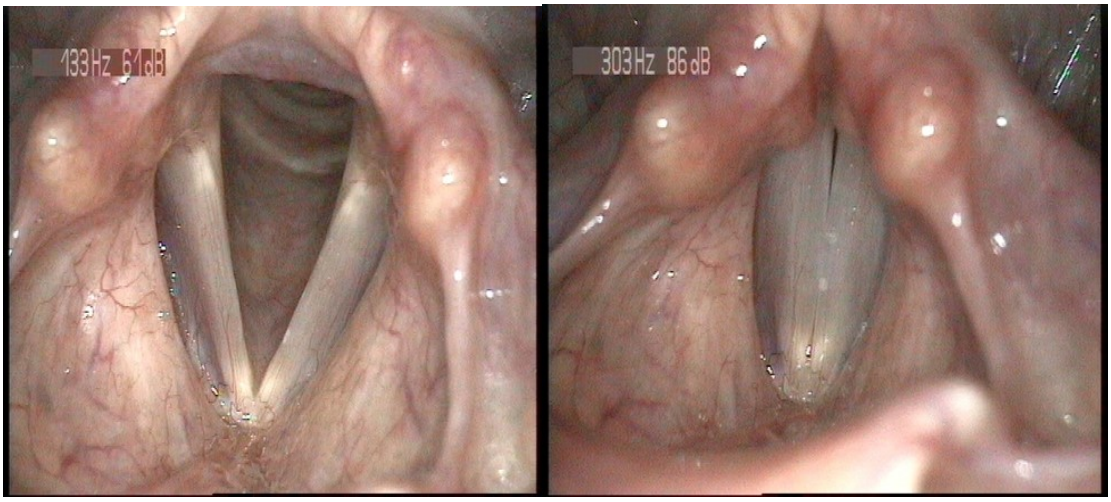


*Figure 3: Laryngostroboscopic images of a female operatic singer (case 2) in inspiratory and phonatory position. No pathological findings were discovered during this exam.*

*Laryngostroboscopic exam* did not reveal any specific pathology (Fig. 3). In contrast, her *VKG exam* revealed an abnormal VKG pattern with a discreet failure of vocal fold vibration on the right side ( Fig. 4). This was found to be due to laryngo-pharyngeal reflux disease (LPRD), which was verified using 24 hour multichannel intraluminal impedance pH.

Therapy: Proton pumps inhibitors

Prognosis: The clinical symptoms and VKG finding was adjusted to normal within 2 weeks.

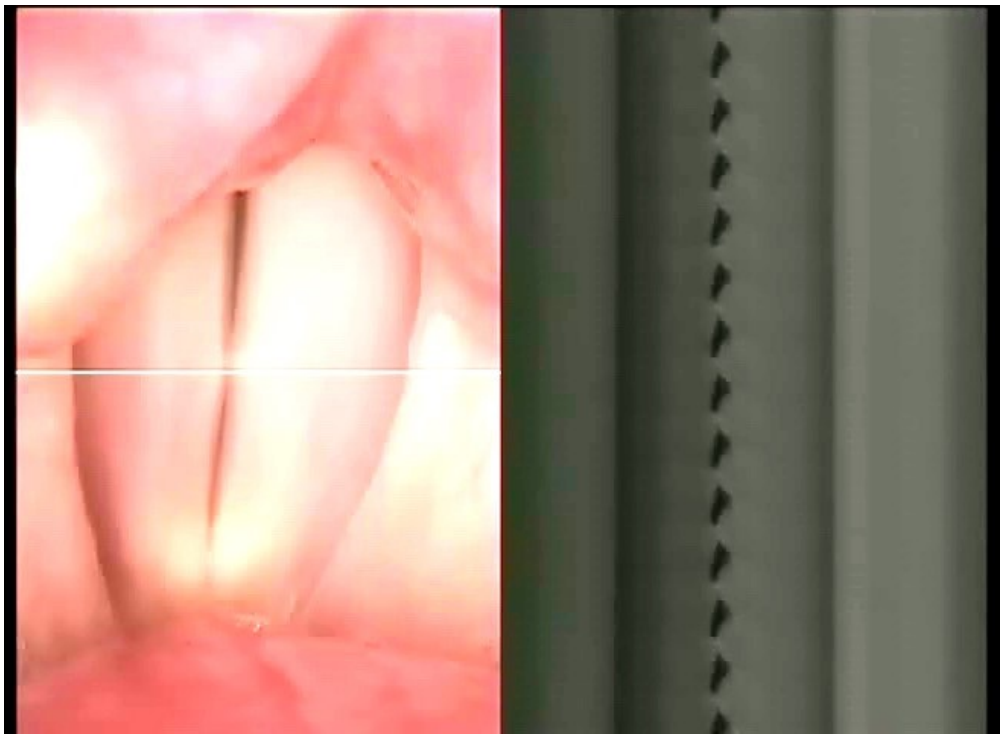

*Figure 4: VKG findings in the same female singer (case 2). The right vocal fold shows remarkably reduced vibration amplitude in the middle of glottal length, which indicates an increased stiffness or scar of the vocal fold tissue. Vibration of the left vocal fold is normal.*

3.3. Case 3:

23-years old male student of operatic singing suffering from vocal fatigue after singing and after longer periods of speaking. His voice was relatively sonorous.

*Laryngostroboscopic examination* did not reveal any major pathology. There was an erythema on the vocal folds and viscous mucus. There was also a small retention cyst on the superior vocal fold surface which did not interfere with the vibrations and thus was considered to have no clinical importance.

*VKG examination* (Fig. 5) revealed major vibration disorder of the vocal folds. Lateral oscillation peaks were remarkably rounded, which indicated an increased stiffness of the mucosa caused by inflammatory infiltration and edema.

*Therapy:* ATB, vocal therapy, anti-edematous therapy

*Prognosis:* The clinical symptoms and VKG finding was adjusted to normal within 3 weeks.

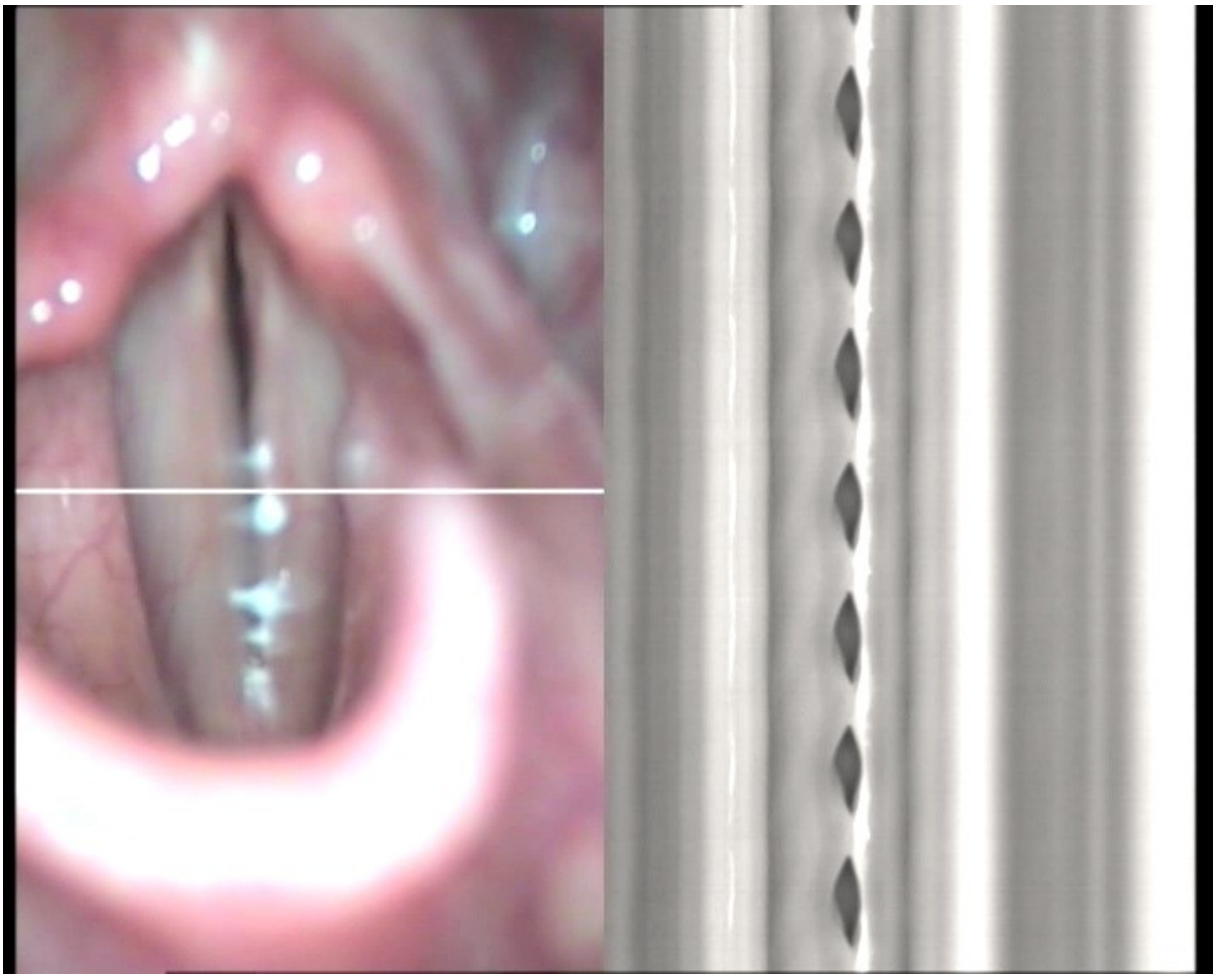

*Figure 5: Images from VKG examination in a patient with inflammatory infiltration of both vocal folds (case 3). The right vocal fold shows rounded shape of lateral oscillation peaks. This finding indicated increased mucosal stiffness due to inflammatory infiltration changes in vocal fold's tissue. The finding on the left vocal fold is even more serious by showing exceedingly reduced vibratory amplitudes.*

**4. Conclusion:**

Videokymography belongs to optical laryngeal examination methods and aims at the diagnosis of vibration disorders of the vocal folds. Vibration disorders are the basis of voice disorders. The special videokymographic camera provides simultaneously both the laryngoscopic as well as kymograpic video images and visualizes the vibratory pattern of the vocal folds at the selected line. This allows discovering minor alterations in vocal fold vibratory patterns. These alterations could be due to inflammatory or tumorous inflitration of the vocal fold tissues. They point at mucosal vocal fold mucosa damages, small scars, dilatations of the submucosal vessels or vocal fold edema of hormonal or allergic origin. Evaluation of the videokymographic findings requires

the knowledge of the normal vibratory patterns and of the relationships between the alterations of the vibratory pattern and the pathophysiology of the vocal fold tissues. We find the method useful for diagnosing organic and functional voice disorders at an early stage. It shows to be particularly helpful for diagnosis of voice professionals and for deciding on their therapy. We find it particularly important for n early diagnosis of vocal fold cancer. It allows detecting pathologic processes at the stages when laryngoscopic and stroboscopic findings appear normal.

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