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## Specific features of vocal fold paralysis in functional computed tomography

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### Summary

**Background:**

Vocal fold paralysis is usually recognized in laryngological examination, and detailed vocal fold function may be established based on laryngovideostroboscopy. Additional imaging should exclude any morphological causes of the paresis, which should be treated pharmacologically or surgically. The aim of this paper was to analyze the computed tomography (CT) images of the larynx in patients with unilateral vocal fold paralysis.

**Material/Methods:**

CT examinations of the larynx were performed in 10 patients with clinically defined unilateral vocal fold paralysis. The examinations consisted of unenhanced acquisition and enhanced 3-phased acquisition: during free breathing, Valsalva maneuver, and phonation. The analysis included the following morphologic features of the paresis: the deepened epiglottic vallecula, the deepened piriform recess, the thickened and medially positioned aryepiglottic fold, the widened laryngeal pouch, the anteriorly positioned arytenoid cartilage, the thickened vocal fold, and the filled infraglottic space in frontal CT reconstruction. CT images were compared to laryngovideostroboscopy.

**Results:**

The most common symptoms of vocal cord paralysis in CT were the deepened epiglottic vallecula and piriform recess, the widened laryngeal pouch with the filled infraglottic space, and the thickened aryepiglottic fold. Regarding the efficiency of the paralysis determination, the three functional techniques of CT larynx imaging used did not differ significantly, and laryngovideostroboscopy demonstrated its advantage over CT.

**Conclusions:**

CT of the larynx is a supplementary examination in the diagnosis of vocal fold paralysis, which may enable topographic analysis of the fold dysfunction. The knowledge of morphological CT features of the paralysis may help to prevent false-positive diagnosis of laryngeal cancer.

**Key words:**

Computed tomography • laryngovideostroboscopy • vocal cord paralysis

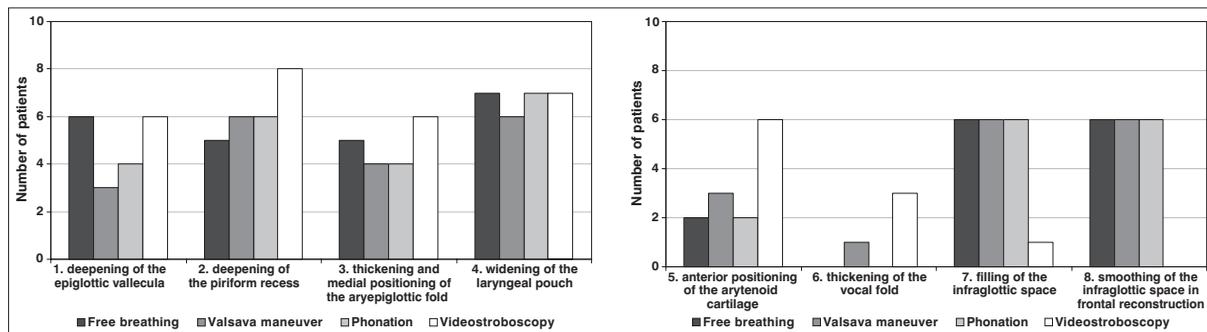
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### Background

Change of the timbre of voice and periodic hoarseness are the clinical symptoms of unilateral vocal fold paresis. The paresis can be caused by vascular, inflammatory and neoplastic changes in the brain stem, skull base, neck and mediastinum, as well as iatrogenic (strumectomy, tracheo-

tomy, intubation). It can also be idiopathic. Vocal fold paresis is detected by laryngological examination, and precise functional assessment of the vocal folds is possible in laryngovideostroboscopy, which remains the standard of phoniatic diagnostics. The aim of imaging is to exclude organic diseases requiring pharmacological or surgical treatment, or to assess the patient postoperatively [1, 2].



**Figure 1.** Comparison of vocal fold paralysis symptoms detected by particular imaging techniques.

The technological progress in multidetector computed tomography increase the potential of larynx imaging owing to higher resolution with shorter acquisition time and larger scope of the scan. This encourages the performance of dynamic laryngeal scans.

The aim of the study was morphological assessment of the larynx with multidetector helical computed tomography in patients with unilateral vocal fold paresis and comparison of CT images with laryngovideostroboscopy.

**Materials and methods**

A group of 10 patients (5 women, 5 men) with clinical unilateral vocal fold paresis, aged 43-57 years (mean age 51 years) was referred to the Computed Tomography Department for exclusion of an organic cause of the paresis. Laryngeal CT scans were performed with a 4-row scanner, before and after intravenous contrast administration with an automatic syringe, in 3 phases: during free breathing (30 s following the start of contrast administration), Valsalva maneuver (180 s), and phonation of the vowel "e".

The following signs of vocal fold paralysis were assessed in the CT scans (fig. 2-6):

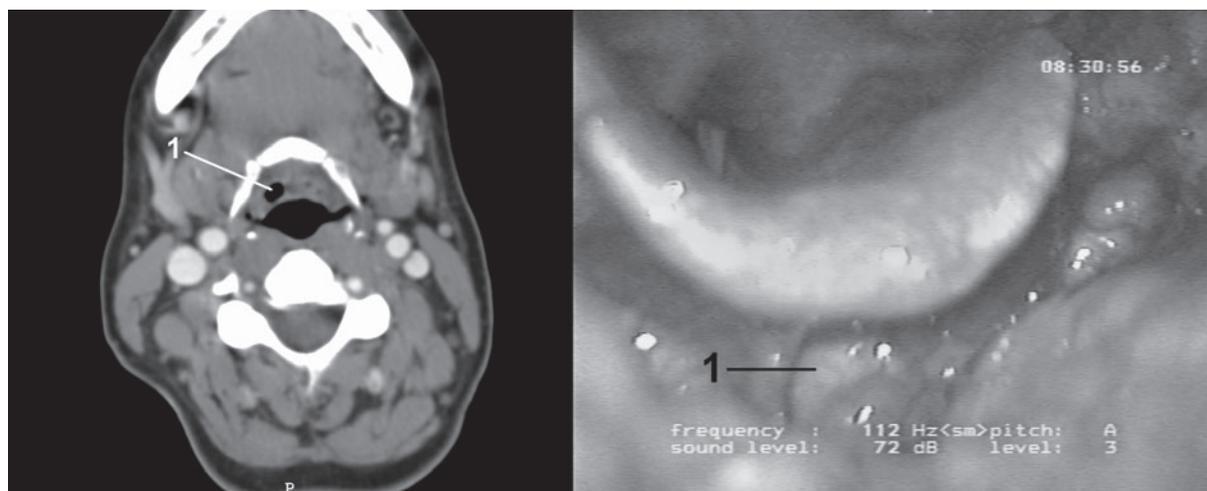
- 1) deepening of the epiglottic vallecula
- 2) deepening of the piriform recess

- 3) thickening and medial positioning of the aryepiglottic fold
- 4) widening of the laryngeal pouch
- 5) anterior positioning of the arytenoid cartilage
- 6) thickening of the vocal fold
- 7) filling of the infraglottic space
- 8) smoothing of the infraglottic space in frontal reconstruction

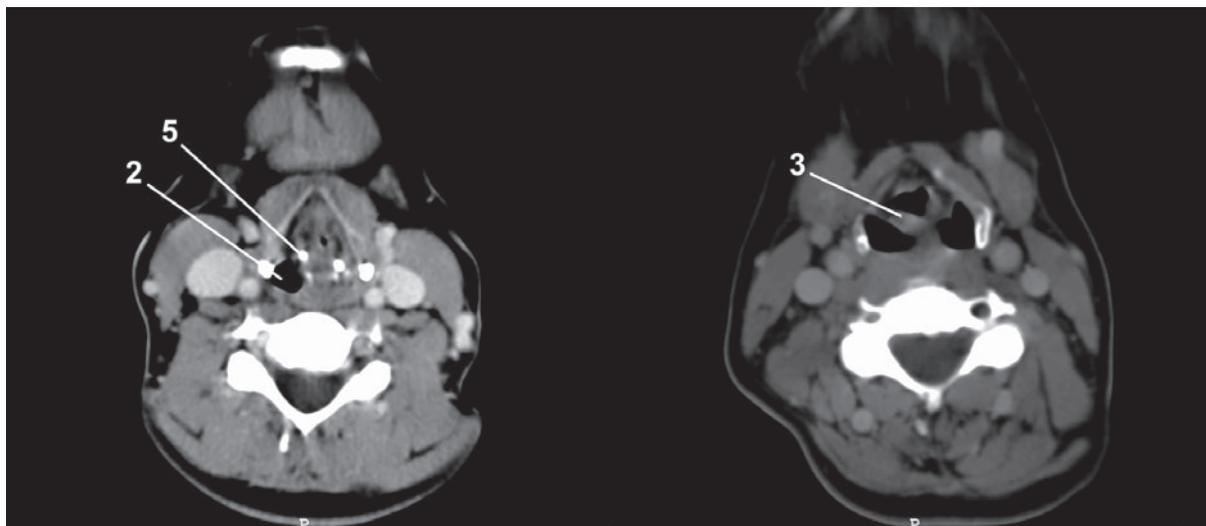
The following scan parameters were applied: helical acquisition 4x3,2 mm, increment 1,6 mm, pitch 1,25, FOV 250, voltage 120 kV, 250 mAs. The radiation dose expressed as CTDI vol. was 17.1 mGy. Before referral to the CT Department, all the patients had undergone laryngological examination with assessment of the larynx by laryngovideostroboscopy. In order to compare the imaging potentials of CT and laryngovideostroboscopy with respect to signs of vocal fold paresis, taking into consideration small size of the studied population, Chi 2 analysis for the observed versus expected quantities was performed. The differences were statistically significant at < 0.05.

**Results**

All the patients had unilateral vocal fold paresis diagnosed by laryngological examination. Laryngoscopy and computed tomography did not reveal in any case pathologic changes within the larynx that could have caused the paresis. The most frequent radiological signs of vocal fold paresis seen



**Figure 2.** Deepening of the epiglottic vallecula (1) in CT and in laryngovideostroboscopy.



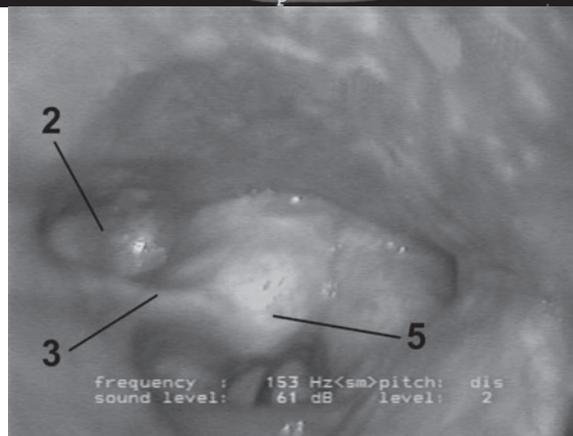
**Figure 3.** Deepening of the piriform recess (2), thickening and medialization of the aryepiglottic fold (3) and anterior positioning of the arytenoid cartilage (5) in CT and in laryngovideostroboscopy.

in CT scans included deepening of the epiglottic vallecula and the piriform recess, widening of the laryngeal pouch, filling of the infraglottic space and thickening of the aryepiglottic fold (Figure 1). Unlike CT, assessment of the infraglottic space obscured by the affected vocal fold, was the most difficult in laryngovideostroboscopy. Anterior displacement of the arytenoid cartilage was seen more frequently in laryngovideostroboscopy than in CT. Apart from that, the results obtained with both methods were similar. With both methods, widening of the vocal fold was observed only in single patients.

Statistical analysis of the 3 techniques used in imaging of the larynx, i.e. free breathing, phonation and Valsalva maneuver, revealed no statistically significant differences in the number of detected signs of paresis ( $p = 0.67-0.98$ ). However, laryngovideostroboscopy, even with its limitations with respect to examination of the infraglottic space, proved to be more effective than CT ( $p < 0.01$ ).

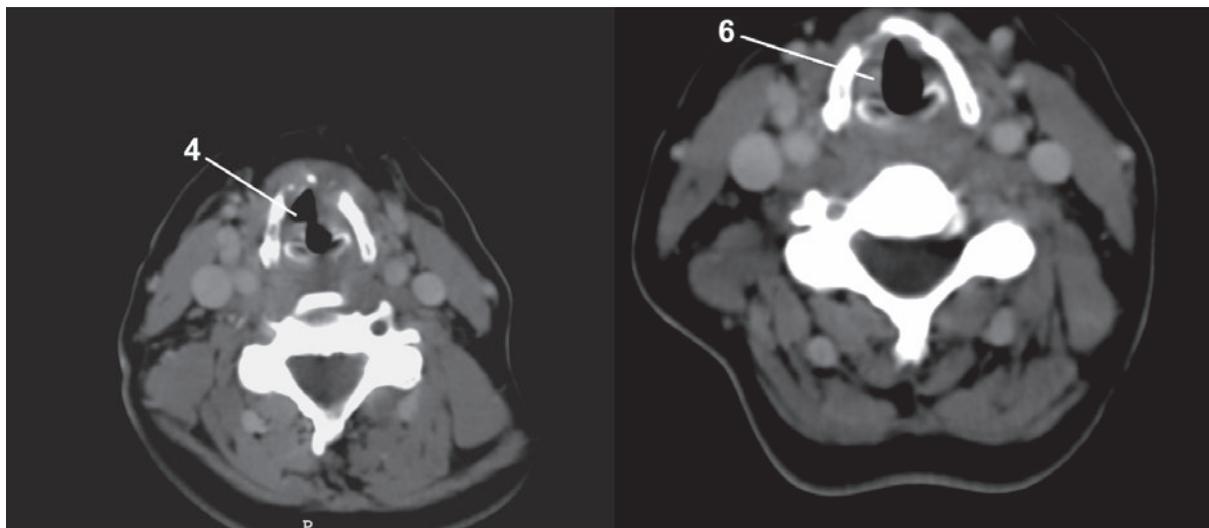
## Discussion

Immobility of the vocal fold on respiration in clinical laryngological examination is a direct sign of its paresis. Such an observation requires extensive and multidirectional diagnostics. In order to institute appropriate conservative or surgical treatment, the cause and level of the paresis should be determined. Radiological and endoscopic examinations, complementary to each other, are performed in each case of uni- or bilateral vocal fold paresis of unknown etiology. [3]. Radiological techniques include routine chest X-ray with assessment of the mediastinum, contrast esophageal radiography and USG of the neck. In particular cases, such techniques are applied as three-dimensional CT, allowing to visualize directly the movement of the vocal folds, especially after laryngoplasty [4], or PET-CT in cases of suspected neoplastic process [5]. Interestingly, patients with unilateral vocal fold paresis demonstrate increased metabolism in the unaffected part of the larynx in PET, which sometimes



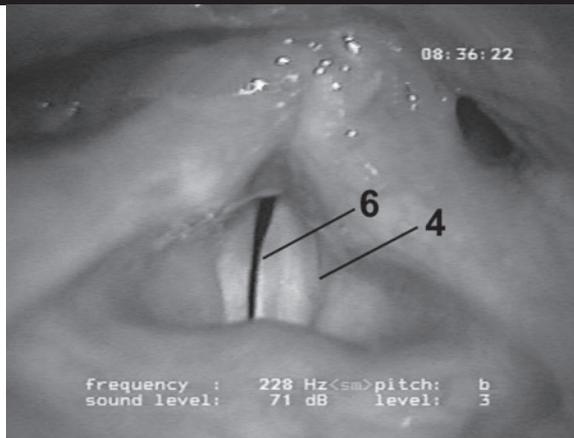
leads to false-positive results, and which, in the authors' opinion, can be explained by increased laryngeal muscle tone [5]. However, classic and functional CT of the larynx, sporadically used to date for its assessment, may be useful in some diagnostic cases as an examination complementary to, or replacing laryngoscopy [6].

The first description of radiological, indirect symptoms of laryngeal paresis was presented by Landman on the basis of laryngographic studies in the 1960's [7]. Currently the possibility of short-time multiphase examinations with multiplanar reconstructions encourages the use of dynamic CT scans of the larynx. Especially extending CT to include the functional phases, i.e. the modified Valsalva maneuver and phonation, improves the quality of imaging of various anatomic structures of the larynx [8]. Modified Valsalva maneuver involves expiration with closed mouth and nose. Performed by the patient during CT, Valsalva maneuver causes widening of the air spaces in the larynx and inferior pharynx, i.e. the piriform recesses and laryngeal pouches, enabling their better visualizations, while the vocal folds are abducted and difficult to assess. The morphology of the vocal and vestibular folds is assessed during phonation, when the "e" vowel is pronounced [8]. The above functional CT phases improve the quality of the scan, especially in patients with laryngeal tumors, facilitating determination of their extent. It is important to rehearse the Valsalva maneuver and phonation immediately before CT.

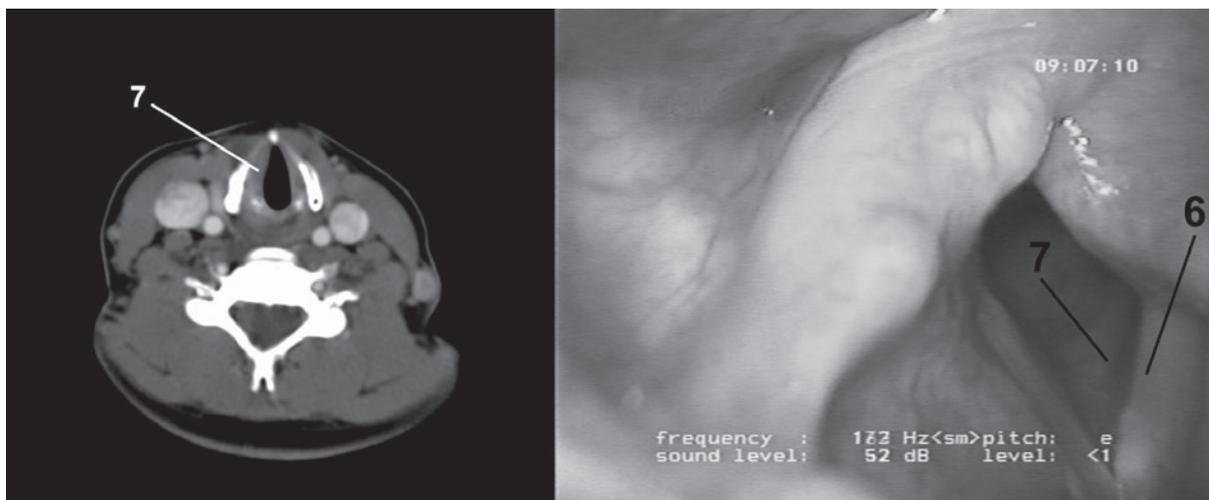


**Figure 4.** Widening of the laryngeal pouch (4) and thickening of the vocal fold (6) in CT and in laryngovideoscopy.

No organic laryngeal abnormalities were observed in the studied group of patients. Statistical analysis revealed no significant differences in visualization of the particular signs of vocal fold paresis in the 3 phases of CT, i.e. free breathing, Valsalva maneuver and phonation. The most frequently observed signs included widening of the laryngeal and inferior pharyngeal air spaces ipsilateral to the paresis, i.e. the laryngeal pouch (70%) and the piriform recess (60%) – fig. 3-6. In 50% of the patients, thickening of the aryepiglottic fold was demonstrated (fig. 3). Depending on the scan phase, deepening of the epiglottic vallecula was seen in 30 to 60% of patients (fig. 2). Among the analyzed signs of vocal fold paresis, anterior displacement of the arytenoid cartilages was seen the least frequently (in 20-30% of patients, depending on the scan phase, fig. 3) and thickening of the vocal fold (only in one patient and only in one scan phase – during Valsava maneuver, fig. 4). Similar results were reported by Chine et al. [9]. In their material, widening of the laryngeal pouch and the



piriform recess were also the most frequently observed signs of vocal fold paresis (in 78% of patients each), whereas anterior displacement of the arytenoid cartilages and thickening of the vocal fold was seen in 50% and 45% of patients, respectively. Deepening of the epiglottic vallecula was the sign observed the least frequently (18%) by these authors.



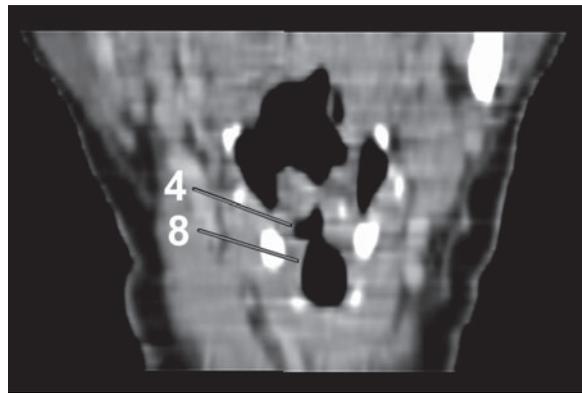
**Figure 5.** Thickening of the vocal fold (6) in laryngovideoscopy and filling of the infraglottic space (7) in CT and in laryngovideoscopy.

Making a phonation attempt by the patient did not improve significantly visualization of the vocal folds in comparison with other phases of CT, which results probably from the absence of morphological changes in the larynx that could make such visualization more difficult. Functional tests seem to have the greatest value in case of neoplastic or inflammatory infiltration, causing thickening and immobilization of some laryngeal structures, or, in case of adjacent tumors, causing compression of the larynx. Additional frontal reconstructions also failed to affect the results of the scan, without significant improvement of its diagnostic quality. Classic transverse reconstructions are sufficient in this case. As the medially positioned vocal fold obscures the infraglottic area in laryngovideostroboscopy, its smoothing was seen only in 1 out of 10 patients. Thus, development of a neoplastic process in the infraglottic area of the larynx can be overlooked in laryngological examination.

Taking into consideration all the signs of vocal fold paresis, they were detected significantly more frequently by laryngovideostroboscopy. In both CT and laryngovideostroboscopy, assessment of the vocal fold thickening was the most problematic: it was detected only in single patients, one in CT and one in laryngovideostroboscopy. It should be emphasized that vocal fold thickening is apparent and may be due to changes in internal laryngeal muscle tone.

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**Figure 6.** Widening of the laryngeal pouch (4) and smoothing of the infraglottic space in frontal reconstruction (8) in CT.

## Conclusions

1. CT of the larynx is a supplementary examination in the diagnosis of vocal fold paralysis, which may enable topographic analysis of the fold dysfunction.
2. The knowledge of morphological CT features of the paralysis may help to prevent false-positive diagnosis of laryngeal cancer.