Routine Computed Tomography in the Evaluation of Vocal Fold Movement Impairment without an Apparent Cause

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Abstract

Objective. Routine computed tomography (CT) for vocal fold movement impairment (VFMI) without an apparent cause is common. However, given increased cancer risk associated with ionizing radiation exposure, our purpose is to evaluate the utility of routine scans for these patients.

Study Design. Retrospective case series.

Setting. Houston, Texas.

Subjects and Methods. A 5-year review of patients with VFMI diagnosed at an academic institution was conducted. For patients without an apparent cause (eg, recent head, neck, or cardiothoracic surgery or known malignancy), CT head/neck and chest was performed to evaluate the recurrent laryngeal nerve course. Data included demographics, symptoms, radiography, and interventions. Statistical analyses were performed via \( \chi^2 \) analysis.

Results. Of 406 patients with VFMI, 47 (11%) patients had no apparent cause clinically. Routine CT revealed abnormalities in 10 (21%) patients, of which only 3 (6%) could account for VFMI: benign thyroid adenoma (1), papillary thyroid cancer (1), and an esophageal mass (1). The most common lesion detected involved the thyroid. Demographic data and symptom type were not significantly associated with detection of a VFMI-attributable lesion on CT. Overall, routine CT did not identify a focal etiology in 94% patients with VFMI without an apparent cause.

Conclusion. Routine pan-CT evaluation failed to reveal an etiology in 94% of patients with VFMI without an apparent cause. Patients may be subjected to health risks associated with radiation exposure without significant diagnostic benefit. Further studies should consider more judicious use of CT in the context of risk factors and safer imaging modalities as the initial diagnostic step.

Keywords

idiopathic, vocal fold paralysis, vocal fold movement impairment, computed tomography

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Vocal fold movement impairment (VFMI) continues to be a common problem in otolaryngology. The immobility arises from mechanical fixation or damage to the recurrent laryngeal nerve fibers, which travel from the brainstem nuclei into the mediastinum, branching from the vagus nerve and coursing around aortic vessels before entering the larynx. Given its extensive course, neurologic impairment may result from a variety of causes, including neoplastic processes, trauma, viral infections, or iatrogenic injury.¹⁻⁴

Establishing the etiology of VFMI is critical to direct management and treatment options. Transient dysfunction from compression or inflammation can be resolved, while neoplastic invasion or traumatic severance of nerve fibers may result in permanent immobility and may benefit from surgical interventions. However, about 24% of cases are found to be idiopathic, or of unknown origin.⁵ These patients present without head or chest surgery or other apparent causal factors. It is possible that VFMI may be an early sign of nerve impairment secondary to subclinical malignancy. Thus, radiographic evaluation from the skull base through the aortic arch is used to exclude occult disease.⁶⁻⁷

The diagnostic workup algorithm for VFMI without an apparent cause relies on imaging as the initial step. Various studies have supported chest x-ray (CXR), ultrasound, and computed tomography (CT) radiography.⁶⁻¹⁰ At our institution, the current protocol when investigating unexplained VFMI is a routine head/neck and chest CT scan with attention to the course of the vagus nerve. However, CT radiation exposure has been associated with increased risk for...
developing secondary cancer. This serious health risk and the lack of evidence-based consensus on the use of CT compel the need for further investigation into its usefulness and necessity. Therefore, the objective of this study is to evaluate the utility of routine CT scans for patients without a clear etiology for their VFMI based on radiographic findings and clinical outcome.

Methods

A 5-year retrospective review (2008-2013) of patients diagnosed with VFMI at an academic institution with multihospital affiliations was performed. Institutional board review approval was obtained from Baylor College of Medicine. Patients with ICD code 478.30-478.34, which encompasses partial or complete vocal fold paralysis, were included. Patients without documentation of a radiographic examination were excluded. The VFMI was established by flexible laryngoscopy. Patients with VFMI without an apparent cause included those without a history of head or neck cancer; advance-staged cancer of another primary source; surgery of head, neck, or chest; local trauma; iatrogenic injury; or prolonged intubation. Patients also did not have any lesions visible on flexible laryngoscopy or physical examination that could account for the VFMI. Per institution protocol, patients received a head, neck, and chest CT as the initial diagnostic imaging.

Variables recorded were demographic data, presenting symptoms (ie, dysphonia, dysphagia), CT radiographic findings, and clinical interventions. Clinical interventions included initiation of antireflux medication, follow-up ultrasonography, biopsy, injection laryngoplasty, and type 1 thyroplasty. A clinically significant finding was defined as a lesion that recommended further evaluation by repeat CT imaging, biopsy, or another imaging modality. A negative radiographic read was based on radiologist documentation that no etiologies or lesions accounting for the VFMI were found. Statistical analyses were done using χ² tests.

Results

Of the 406 patients with vocal fold paralysis (VFP), 47 (11%) had no apparent cause clinically. The patients’ demographic data are summarized in Table 1. The mean age of the patients was 54 ± 12 years (range, 24-81 years), and 57% were female. Left, right, and bilateral VFMI were present in 31 (66%), 13 (28%), and 3 (6%) patients, respectively. The most common presenting symptom was dysphonia (81%), followed by dysphagia (40%), cough (21%), and respiratory distress (13%). Ninety-three percent of patients had symptom duration greater than 1 month. Three (6%) patients were asymptomatic and were found to have unilateral VFMI on routine examination for a primary complaint of nasal polyps (2 patients) and tinnitus (1 patient).

Routine CT imaging revealed lesions in 10 (21%) of the patients (Table 2). Thyroid abnormalities, the most common finding, were reported in 5 (11%) patients, all of whom underwent follow-up ultrasound evaluation with possible biopsy. Two patients had lesions that could have contributed to their left vocal fold immobility. Specifically, patient 1 had a tracheoesophageal mass on CT, found to be a benign adenoma on biopsy, and patient 2 had a dominant lesion later confirmed to be papillary thyroid carcinoma. The thyroid findings in the 3 remaining patients (patients 3-5) were determined to be noncontributory to their VFMI based on the ultrasonographic location and characteristics of the lesions (Table 2).

Of the remaining 5 patients with anomalies other than thyroid, only 1 had a lesion that was ultimately determined to be the cause of his vocal fold immobility. Patient 6 was a 30-year-old man with HIV admitted because of symptoms of weight loss, hoarseness, and cough concerning for infectious, inflammatory, or malignant etiologies. CXR demonstrated a
normal mediastinum without masses, and his cough was initially attributed to early pneumonia. However, inpatient otolaryngologic evaluation identified a left VFMI on flexible nasolaryngoscopy. At outpatient follow-up, a CT showed diffuse esophageal dilatation. The patient was referred to gastroenterology, and biopsy revealed esophageal adenocarcinoma with possible impingement on the recurrent laryngeal nerve.

Three (6%) patients (patients 7-9) were found to have lymphadenopathy on CT that resulted in further evaluation. All 3 patients had a history of tobacco use. These lymph nodes were deemed to be noncontributory to the VFMI based on location and further evaluation via fine-needle aspiration (FNA). Repeat imaging (based on location and further evaluation via fine-needle aspiration) was thought to account for VFMI. However, no demographic variable was significantly associated with finding a lesion on CT imaging. However, no demographic variable was significantly associated with finding a VFMI-attributable lesion on CT.

### Statistical Analysis

Age ($P = .16$), gender ($P = .74$), type of VFMI, and most types of symptoms were not associated with detection of a clinically significant lesion on CT head/neck and chest ($P = .03$). Symptom duration of 1 to 6 months ($P = .03$) were correlated with finding a lesion on CT imaging. However, no demographic variable was significantly associated with finding a VFMI-attributable lesion on CT.

### Discussion

Increasing recognition of the health consequences from cumulative CT-derived radiation exposure has directed efforts to use safer imaging modalities. It is estimated that 0.7% to 2% of cancers in the United States are attributed to CT radiation exposure, with the higher lifetime attribute risk in patients with recurrent CT scans. In patients presenting with VFMI without an initially clear etiology are subjected to diagnostic imaging to exclude subclinical neoplasms. The optimal imaging algorithm, however, remains debatable and not well supported by evidence-based medicine. Several reports suggest CT imaging as a sensitive and efficient means of detecting occult tumors, as CT revealed an identifiable cause in 24% to 36% of cases.

In comparison, our study showed that CT head, neck, and chest failed to find a focal pathology in more than 90% of our patients. This difference may be accounted for by different patient populations in other countries and thus separate environmental and possible genetic factors. Our study also included vocal fold paresis and thus has a much lower "hit" rate than studies limited to paralysis. In a similar retrospective study by Badia et al., 98% of patients with idiopathic unilateral vocal fold paresis had a normal CT scan. The prevalence of negative findings in our study compels careful

### Table 2. Clinically Significant Radiographic Lesions Detected by CT or Ultrasound for Evaluating VFMI without an Apparent Etiology.

<table>
<thead>
<tr>
<th>Patient</th>
<th>CT Findings</th>
<th>Ultrasound</th>
<th>Evaluation Results</th>
<th>VFMI Accountable</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TE groove mass</td>
<td>Dominant nodule at</td>
<td>Adenoma</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>Thyroid nodule</td>
<td>Solid nodule</td>
<td>Papillary thyroid carcinoma</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>Hypodense thyroid nodules</td>
<td>Colloid cysts</td>
<td>Benign</td>
<td>No</td>
</tr>
<tr>
<td>4</td>
<td>Thyroid nodule</td>
<td>Bilateral nodules &lt;</td>
<td>Benign</td>
<td>No</td>
</tr>
<tr>
<td>5</td>
<td>Heterogenous enlarged thyroid</td>
<td>Unremarkable thyroid</td>
<td>Benign</td>
<td>No</td>
</tr>
<tr>
<td>6</td>
<td>Esophageal dilatation</td>
<td>N/A</td>
<td>Adenocarcinoma</td>
<td>Yes</td>
</tr>
<tr>
<td>7</td>
<td>Spiculated left upper lobe nodule</td>
<td>N/A</td>
<td>FNA biopsy: benign</td>
<td>No</td>
</tr>
<tr>
<td>8</td>
<td>Nonspecific cervical lymphadenopathy</td>
<td>N/A</td>
<td>Repeat CT: stable</td>
<td>No</td>
</tr>
<tr>
<td>9</td>
<td>Nonspecific thoracic lymphadenopathy</td>
<td>N/A</td>
<td>Repeat CT: stable</td>
<td>No</td>
</tr>
<tr>
<td>10</td>
<td>Right vocal fold mass</td>
<td>N/A</td>
<td>Flexible laryngoscope: prolapsed arytenoid</td>
<td>Repeat CT: no mass</td>
</tr>
</tbody>
</table>

Abbreviations: CT, computed tomography; FNA, fine-needle aspiration; N/A, not applicable; TE, tracheoesophageal; VFMI, vocal fold movement impairment.
reconsideration of its routine use in light of its radiation-associated cancer risk.

Other modalities (eg, ultrasonography and CXR), may be reasonable alternatives as the initial test before requesting a CT scan. Of the 5 patients with thyroid abnormalities detected on CT, all lesions were detectable by ultrasound, including the 2 lesions that likely accounted for the VFMI. Ultrasound has certain advantages as it can be performed in the office setting and has high sensitivity for detecting thyroid and regional anatomical abnormalities. Furthermore, fine-needle aspiration or core needle biopsy may be performed simultaneously for suspicious lesions. Wang et al demonstrated that high-resolution neck ultrasound could detect subclinical thyroid carcinoma, laryngeal nerve tumors, lymphadenopathy, and cervical esophageal tumors in patients with unilateral VFMI. Similarly, Kang et al found that ultrasonography could identify all cervical lesions detected by CT for patients with no apparent cause of their VFMI.

CXR is commonly employed as the first radiographic modality in evaluation of cardiopulmonary abnormalities in ambulatory settings. Altman and Benninger suggested starting with CXR as compressive intrathoracic lymph nodes or large aortic aneurysms may be visible. The American College of Radiology finds chest radiography useful in diagnosing or ruling out obstructive arch diseases and vascular rings in the absence of acute chest syndrome or trauma. Although some studies recommended routine use of CT imaging for VFMI, Liu et al demonstrated that the economic cost per true-positive case in patients with low suspicion for malignancy was about 5 times higher than in those with high suspicion. In the United States, head/neck and chest CT imaging ($929) is estimated to be about 3.7 times the price of a head/neck ultrasound ($206) and CXR ($46) combined. This places both a financial and health risk burden. In our study, if the patients with cervical lesions detected sonographically (5 patients) and those with spontaneous resolution of symptoms (9 patients) were to defer CT imaging, these 14 patients would have led to cost savings of $9478 in our institution.

In addition, CT imaging may overestimate the pathology of radiographic findings. A patient in our study had a CT finding misinterpreted to be a mass concerning for malignancy and underwent repeat CT to reconfirm benign physical examination findings. Also, the patients with nonspecific lymphadenopathy, found benign and stable, received repeat scans and/or fine-needle aspiration biopsy. It is estimated that incidental masses can occur in 3% to 14% of CT screenings, resulting in possible extensive follow-up, unnecessary radiation or invasive procedures, and patient anxiety. Also, 9 (18%) patients with negative CT findings had improved within several months without any interventions. Comparatively, a meta-analysis by Sulica found that 39% of patients with idiopathic VFP had some recovery of movement typically within 1 year, which may indicate a subclinical viral infection or a transient inflammatory process. Observation may be a reasonable alternative for patients with short symptom duration, especially if initial safer radiographic modalities such as ultrasound reveal no suspicious masses. Consequently, CT could be reserved for persistent or progressive cases.

On the other hand, consideration of risk factors or systemic symptoms for nonthyroid malignancy or systemic illnesses may justify CT radiography as the initial diagnostic tool. Immunocompromised states such as HIV put patients at higher risk for subclinical masses, and dysphagia symptoms may more likely result in a positive finding on CT. In our study, the HIV-positive patient with esophageal dilatation on CT had a mediastinum within normal limits on recent CXRs. Because his immunocompromised condition poses significant risk for development of opportunistic diseases and malignancy, a negative CXR would not have precluded further evaluation with CT among other studies. Furthermore, several patients had a smoking history and were at a higher risk of developing cancer. Recently, low-dose CT chest imaging has been recommended for lung cancer screening in tobacco users because of early detection and reduced mortality benefit. Head and neck low-dose CT protocols have also been demonstrated to be effective in cases such as VP shunt evaluation for pediatric patients. Radiation dosages of standard versus low-dose scans are estimated to be 2 mSv versus <1 mSv in head/neck CT and 10 mSv versus 2 mSv in chest CT. Low-dose CT may be an alternative with its advantage of minimizing ionizing radiation.

It is also important to consider medical and legal consequences for deferring CT evaluation; failure to diagnose could be a serious and litigious consequence. Therefore, it is imperative that a thorough disclosure between patient and physician should be documented. As thyroid and cervical lesions were the most common lesions that could potentially cause the VFMI, it can be explained that it would be safer and more efficient to elect for ultrasound first as it has high sensitivity in finding these lesions. To mitigate the risk of failure to detect an occult malignancy, proper follow-up would be necessary. Fear of litigation should not be the primary guiding decision-making factor, and clinical providers are ethically responsible to provide care with judicious use of resources. Therefore, we propose a diagnostic algorithm for the workup of patients without a clear etiology for VFMI (Figure 1).

Overall, routine CT scans at standard radiation doses may be exposing patients to unnecessary radiation when safer imaging modalities could be used initially to detect possible lesions. Timing and duration of symptoms, patient risk factors, and availability of modalities with minimal radiation should be taken into account when evaluating for subclinical pathologies by CT. In the absence of significant risk factors or systemic symptoms, it may be safer and less costly to the patient to first undergo ultrasound and CXR. Future directions would include prospective studies determining the cost-effectiveness in ultrasonography/CXR versus CT and failure-to-diagnose rate. Because of the rare incidence of patients with VFMI without an apparent cause, our data represent a preliminary look into this area that could be better studied in a multicenter consortium with a larger patient population database.
Limitations

Limitations of this study include that it was a retrospective review with a relatively small sample size. In addition, patients with VFMI presented to the clinic at variable times in their disease course, ranging from weeks to years. Also, CXR was not routinely done, which limits the inferences about the utility of CXR in our study. A prospective trial comparing CT, ultrasound, and CXR modalities would provide more accurate information and implications on patient care. Subjective reporting of symptoms and incomplete histories may have overestimated the number of patients with IVFP, but standard templates for medical records were designed to capture pertinent information. As our patient population included vocal fold paresis and paralysis, this should also be taken account to when generalizing to other patient populations.

Conclusion

The routine use of CT radiography did not reveal a focal etiology in 94% of patients without an apparent cause for their VFMI in our study. A more judicious use in CT imaging is warranted given cancer-related health risks and cost. The feasibility of ultrasonography concomitant with the high rate of negative CT findings and cost estimates support deferring routine CT imaging for other imaging modalities. Further prospective investigation into these alternative approaches would provide greater information on their diagnostic benefit.

Author Contributions

Diane W. Chen, data collection, analysis, interpretation, manuscript drafting and revision, final approval; Alex Young, data collection, interpretation, manuscript drafting, final approval; Donald T. Donovan, study design, manuscript revision, final approval; Julina Ongkasuwan, study design, interpretation of data, manuscript revision, final approval.

Disclosures

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