ORIGINAL ARTICLE

WHEN THE SILENCE PREVAILS, IMAGES TALK: THE CHARACTERISTIC CT FEATURES OF VOCAL CORD PARALYSIS, CAUSES OF MISSED PALSY BY RADIOLOGISTS AND MIMICS OF VOCAL CORD PALSY UNVEILED

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Background: Causes of vocal cord palsy (VCP) can be identified even before its clinical presentation if a radiologist has knowledge about signs of vocal cord palsy, its various mimics and the anatomy of recurrent laryngeal nerve. Objectives are to know the signs and underlying causes leading to VCP and various mimics which may lead to the false positive diagnosis of VCP. **Methods:** A retrospective cross-sectional pilot study comprising 54 patients with vocal cord palsy proven by IDL was conducted. 3 groups were identified. The first group comprised missed VCP on cross-sectional imaging. The second group was, of missed cause of VCP in patients with clinical diagnoses. The third group was patients with mimics of the palsy. **Results:**Thirteen (76.5%) patients had missed diagnosis due to lack of knowledge of signs and 23.5% due to lack of time, overwork and tiredness. A vigilant search for the cause was not done in 31.6% of patients and in 68.4% of patients, the cause was identified but not correlated. A total of 8 patients had false positive diagnoses due to failure to differentiate from mimics. **Conclusion:** There is an increasing trend of missed diagnosis of vocal cord palsy on cross-sectional imaging in patients with established clinical diagnosis due to a lack of knowledge of VCP signs and missed causes along the course of recurrent laryngeal nerve.

Keywords: Vocal cord; Palsy; Cross-sectional anatomy; Mimics

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INTRODUCTION

A radiologist must be aware of the detailed anatomy of the vagus as well as recurrent laryngeal nerve (RCLN) and the spectrum of pathological conditions along their course which can result in paralysis, the signs which can help make a confident diagnosis of vocal cord paralysis on cross-sectional imaging (CT and MRI) and mimics of vocal cord palsy.

Recognition of a structure as minute as cranial nerve is not possible on cross-sectional imaging; therefore, knowledge of anatomy is essential to search for related pathology along its course[1]. For complete evaluation, cross-sectional images are obtained from the skull base till upper mediastinal level [2].

True cords are identified at the level of cricoarytenoid joints and paramedian sagittal reformat images at this level are obtained. Thin slices allow oblique images to be reconstructed. 3-D image reconstruction can also be done and this is particularly helpful in patients with laryngeal trauma in whom a displaced arytenoid cartilage can be more reliably evaluated[3] which is a mimic of a paralyzed cord.[4]

A know-how of cross-sectional imaging signs[2] is essential for a confident diagnosis of vocal cord paralysis (VCP). Lack of knowledge may lead to incorrect interpretation with the diagnosis being missed[5]. The most sensitive signs are ipsilateral piriform sinus dilatation, medial rotation and thickening of aryepiglottic fold and ipsilateral laryngeal ventricle dilatation.

Others include" sail sign"[5,6] in which paralysis of the thyroarytenoid muscle causes medial deviation of the posterior aspect of the vocal cord and air-distended ipsilateral laryngeal ventricle, the combination of which causes the residual airway to have a shape same as a ship's sail.

On coronal images, the angle between the inferior margin of the true cord and the subglottic larynx appears acute during the Valsalva manoeuvre or phonation. In VCP there is flattening of this angle due to medial deviation of cord[7].

"Mushroom sign"[5,6] is seen on oblique axial cross-sectional images at the level of true cords. Subglottic air is seen anteriorly contralateral to the dilated laryngeal ventricle on the same side of the paralyzed cord. This appears as a mushroom with a stem between the posterior vocal cord margin and the head towards the side of VCP. It is important to remember that oblique images can cause a false positive appearance of VCP as anterior subglottic air may imitate a dilated laryngeal ventricle.[5]

Paralyzed cord fails to adduct. Hence in breath-hold images, the contralateral cord will extend more medially than the normal to compensate for the lack of adduction of the other cord leading to a convex appearance of the normal cord towards the other cord.[7]

Finally, it is essential to know the various mimics of VCP in order to avoid any false positive diagnosis of VCP and to avoid misinterpretation of other diagnosis.[8]

This includes oblique imaging as already discussed. Neck malignancies especially those of larynx and pyriform sinuses and arytenoid cartilage fracture and dislocation are amongst the many others[5]. Vocal cords can also be involved by regional infiltrative neoplasm or fibrotic conditions[9] which immobilize the cord when its motor innervation is still preserved. Arytenoid cartilage fracture and dislocation may follow difficult intubation or blunt trauma. Coronal cross-sectional and 3-D images will be helpful in showing the loss of normal alignment of the cricoarytenoid joint and incongruence in the heights of vocal cords[10] which is not a feature of VCP. A head tilt can lead to an asymmetrical appearance of cords which may be misinterpreted as paralysis[8]. Following injection laryngoplasty treatment for VCP the paralyzed cord is medialized to improve closure of rima glottidis during swallowing and respiration. Prosthesis material must be identified on cross-sectional imaging in correlation with history to avoid misreporting these as traumatic foreign bodies or laryngeal masses.[11]

MATERIAL AND METHODS

We conducted a retrospective cross-sectional pilot study of 54 patients with vocal cord palsy referred from various departments at a tertiary care centre. Our study was approved by the International Review Board of our hospital. The study included 47 males and 7 females. A record search was made in Picture Archiving and Communication System (PACS) data from census dating from January 2019 back to January 2015 using search words “vocal cord palsy”, “vocal cord palsies”, “vocal cord thickening”, “IDL” “hoarseness”, “aspiration” and “difficulty speaking”. All of these patients had symptoms of vocal cord palsy. A few of these had systemic symptoms, including hemiplegia, numbness and weakness of upper and lower extremities, weight loss, shortness of breath, thyroidectomy for multi-nodular goitre (MNG) or thyroid malignancy, neck trauma, diffuse sweating and generalized body weakness. We included patients with established diagnoses of VCP by indirect laryngoscopy (IDL) and referred by primary physicians which are mostly Ear Nose and Throat (ENT) surgeons. These patients clinically or radiologically had a systemic cause leading to VCP. We studied variables of age, laterality of vocal cord abnormality and CT signs of vocal cord paralysis amongst those in whom the diagnosis was missed. Additional tests such as Magnetic Resonance Imaging (MRI), barium swallow, and thyroid ultrasound were simultaneously reviewed. Confidential file data of these patients was retrieved and the clinical examination and any surgical data were reviewed. The possible cause of palsy was retrospectively looked for in cross-sectional images reviewed on PACS. Data was analyzed on SPSS v21. All patient record data was kept confidential.

In our descriptive analysis, we studied the frequency and percentage of missed vocal cord palsy on a cross-sectional study of patients who presented with clinical history or signs of palsy and subsequently had their diagnosis confirmed with IDL. Images were reviewed by two senior radiologists and cases which were missed were discussed with the reporting radiologist for the cause of miss including lack of knowledge of cross-sectional imaging signs of paralyzed cord, lack of time due to over-work and tiredness. The signs of vocal cord palsy were studied on cross-sectional imaging and quantified by frequency and percentages which enabled us to determine which one of the signs was most to least prevalent in our patients.

Our study also included the frequency and percentage of missed cause of VCP in patients in whom cross-sectional imaging signs of palsy were identified and hence a confident imaging diagnosis of VCP was made but it was not correlated with the established clinical cause of palsy. These patients were dissected into those in whom a vigilant search for the cause was not done and those in whom the cause was identified but not correlated as being responsible for palsy due to lack of recall of anatomy of the neurogenic supply of cord. Images were again reviewed by two senior radiologists and cases which were missed were discussed with the reporting radiologist who retrospectively was made to review the cross-sectional images and to fill out a questionnaire to tick the cause of their appropriate setting. Finally, patients falsely diagnosed as palsy due to failure to differentiate paralyzed cord from mimics of paralyzed cord were also included.

Ten patients were excluded from our study. These included those who had VCP diagnosed by IDL but had no identifiable cause clinically, on examination as well as cross-sectional imaging. Patients who did not have vocal cord palsy on IDL were also excluded.

Quantitative comparison among the patients in each group was carried out with frequency and percentages. Further dissection of identification of vocal cord palsy signs recognized retrospectively was quantitatively also compared by frequency and percentages to determine the most to least identified sign. Observation bias was controlled by using only two senior radiologists to report the cross-sectional images of included patients in our study. Selection bias was controlled by including all patients who were searched in PACS and met our inclusion criteria.

RESULTS

A total of 44 patients were included. 20 of all patients had left-sided vocal cord involvement (46.5%), 18 had right-sided involvement (41.9%) and 5 had bilateral involvement (11.6%). 17 patients of age range 24–78 years (mean 58.9±16.26) had VCP but the diagnosis was missed. In 13 patients (76.5%) there was a lack of knowledge of cross-sectional imaging signs while in 4 (23.5%) diagnosis was missed due to lack of time, overwork and tiredness. A retrospective review of cross-sectional images for identification of signs revealed ipsilateral pyriform sinus dilatation in 11.8% patients, medial rotation and thickening of aryepiglottic folds in 35.3% patients, ipsilateral laryngeal ventricle dilatation in 23.5% patients, Sail sign in 11.8% patients, flattened subglottic arch in 5.9% patient, mushroom sign and failure to adduct with more contralateral deviation of cord in 2.3% patient. Overall medial rotation and thickening of the aryepiglottic fold was the most prevalent sign followed by ipsilateral laryngeal ventricle dilatation (figure 2, figure 3, figure 4, figure 5, figure 6 and figure 7). In nineteen patients aged 34 and 82 years (mean 62.57±17.65), VCP was identified but the cause was missed or not correlated. A vigilant search for cause was not done in 6 patients (31.6%) and, in 13 (68.4%) patients the cause was identified but not correlated. Further dissection of causes is given in Figure 1. These patients had a diagnosis of VCP confirmed by IDL in the ENT department.

In 8 patients of age range between 31 and 84 years (mean 61.62±19.22), a false positive diagnosis was made due to failure to differentiate from mimics. The mimics included oblique imaging in 3 patients (37.5%), adjacent fibrosis or malignant invasion in 2 patients (25%), tilted patient and swallowing in 3 patients (37.5%). These patients were diagnosed as being negative for VCP by IDL and had alternative diagnoses responsible for symptoms similar to VCP, the most common of which was pharyngitis, laryngitis and psychological causes.

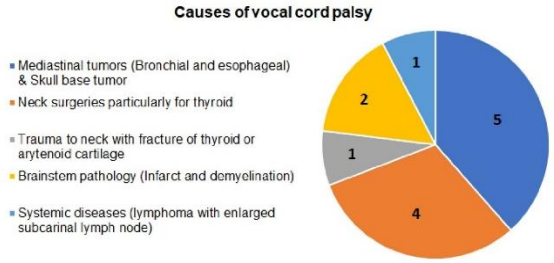

Figure-1: Frequency of causes among patients whom the diagnosis of vocal cord palsy was made but the cause was missed

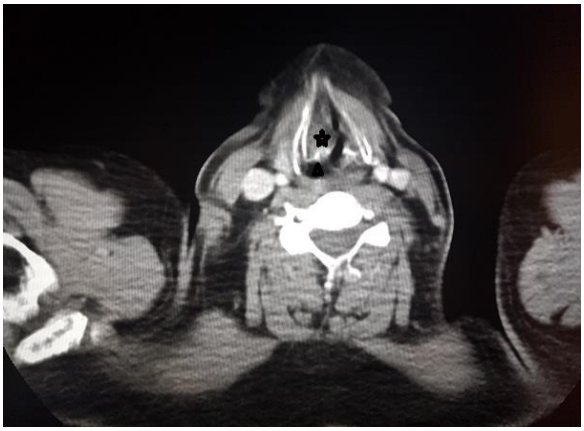

Figure-2: Selected CT axial post-contrast image at the level of true cord

The image shows a sail sign in which paralysis of the thyroarytenoid muscle causes medial deviation of the posterior aspect of the vocal cord (indicated by a star in the image) which causes the residual airway to have a shape same as a ship's sail. Dilatation of ipsilateral pyriform sinus (indicated by triangle) is also evident.

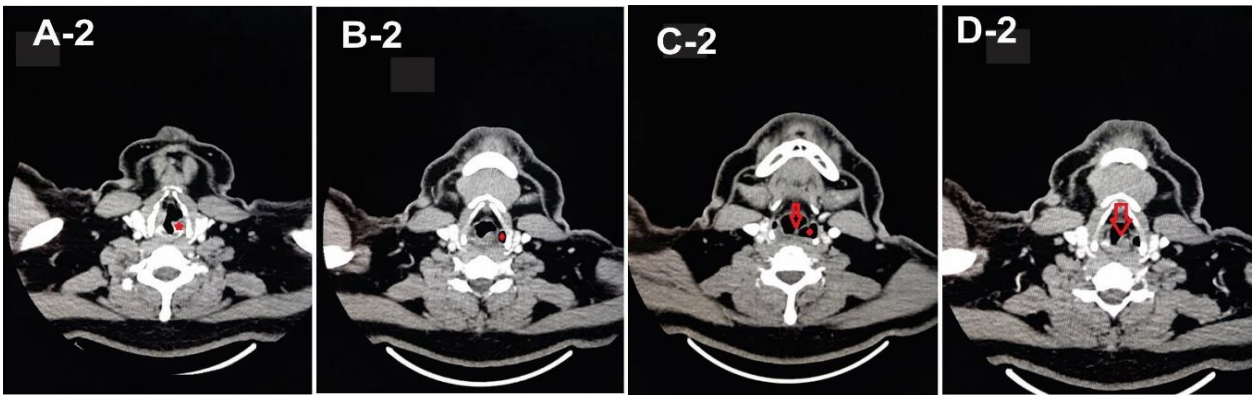

Figure-3: Selected axial CT post-contrast images show left vocal cord paralysis

Selected axial CT post-contrast images show left vocal cord paralysis with a medial deviation of the posterior aspect of left true cord indicated by a star in the image (A-2), left dilated pyriform sinus indicated by diamond in images (B-2 and C-2), and medial rotation and thickening of aryepiglottic fold marked by the red arrow in images (C-2 and D-2).

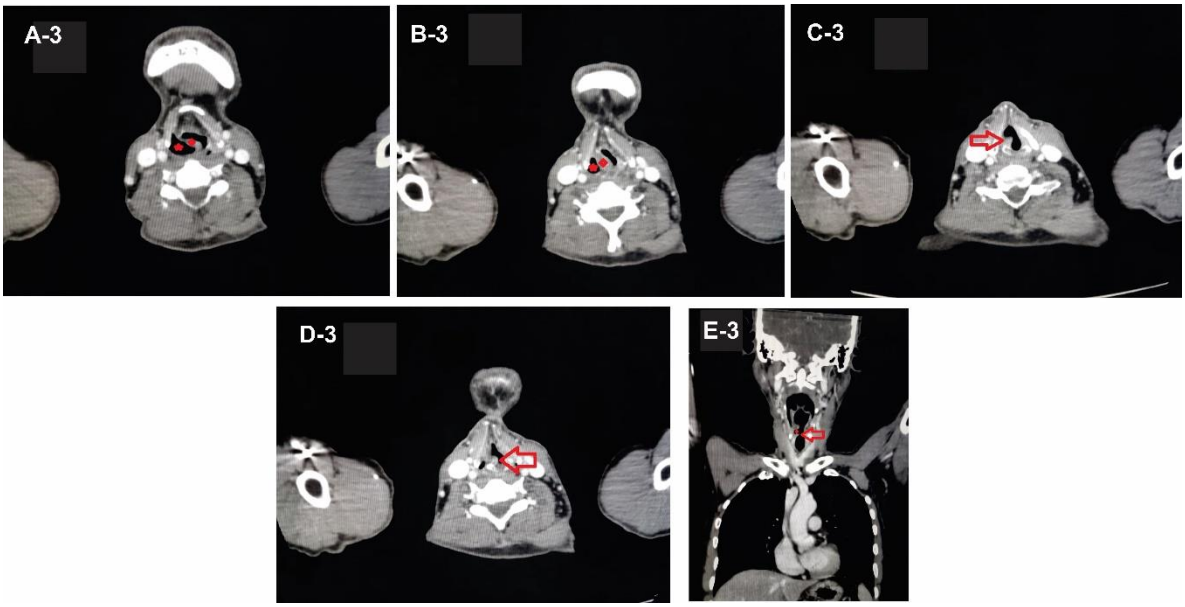

Figure-4: Selected axial CT post-contrast images show right vocal cord paralysis

Selected axial CT post-contrast images show right vocal cord paralysis medial rotation and thickening of aryepiglottic fold indicated by diamond and dilatation of ipsilateral pyriform sinus indicated by a star in images (A-3 and B-3), the sail sign with a medial deviation of the posterior aspect of vocal cord indicated by red arrows in images (C-3 and D-3). The dilated laryngeal ventricle indicated by diamond and medially deviated right vocal cord marked by red arrow is well appreciable on coronal post-contrast image (E-3)

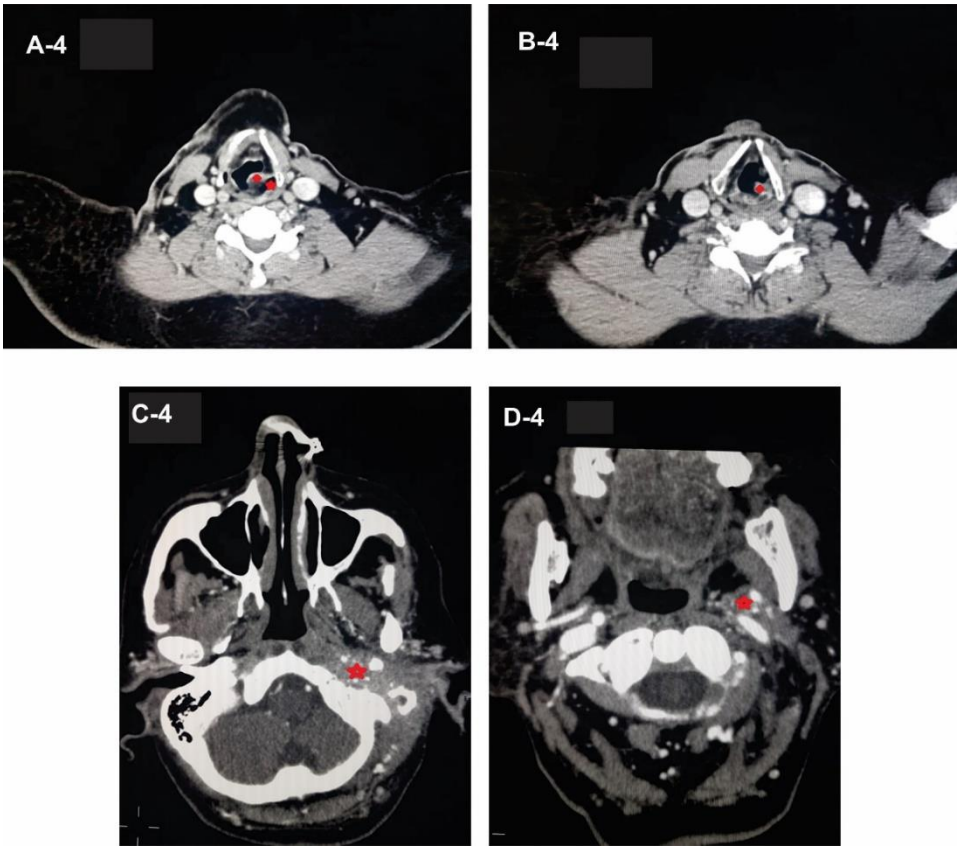

Figure-5: Selected axial CT post-contrast images show left vocal cord paralysis

Selected axial CT post-contrast images show left vocal cord paralysis with medial rotation and thickening of aryepiglottic fold indicated by diamond, and dilatation of ipsilateral pyriform sinus indicated by a star in images (A-4 and B-4). The patient has a soft tissue destructive lesion in the left carotid space indicated by a star in images (C-4 and D-4) with involvement of the left recurrent laryngeal nerve in this location and resultant paralysis

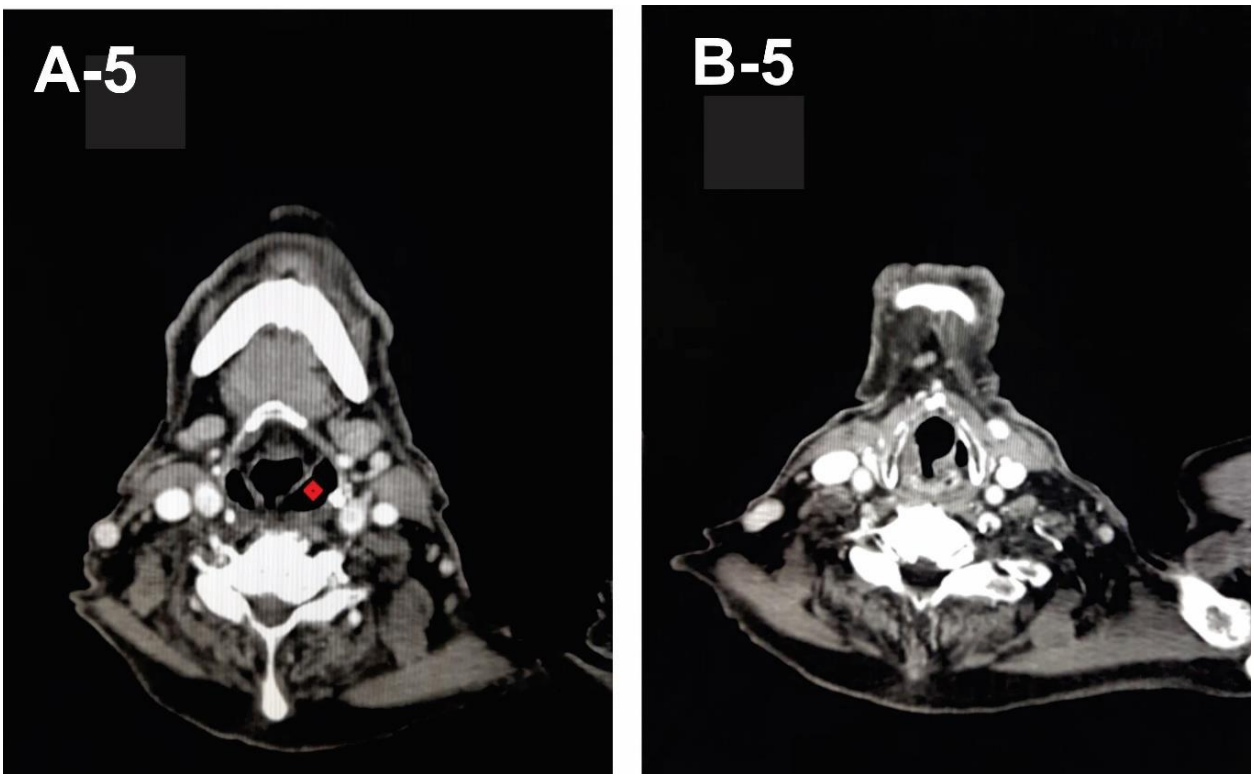

Figure-6: Left vocal cord paralysis

Image (A-5) shows dilated left pyriform sinus indicated by diamond, and image (B-5) at the level of true cords demonstrates the sail sign

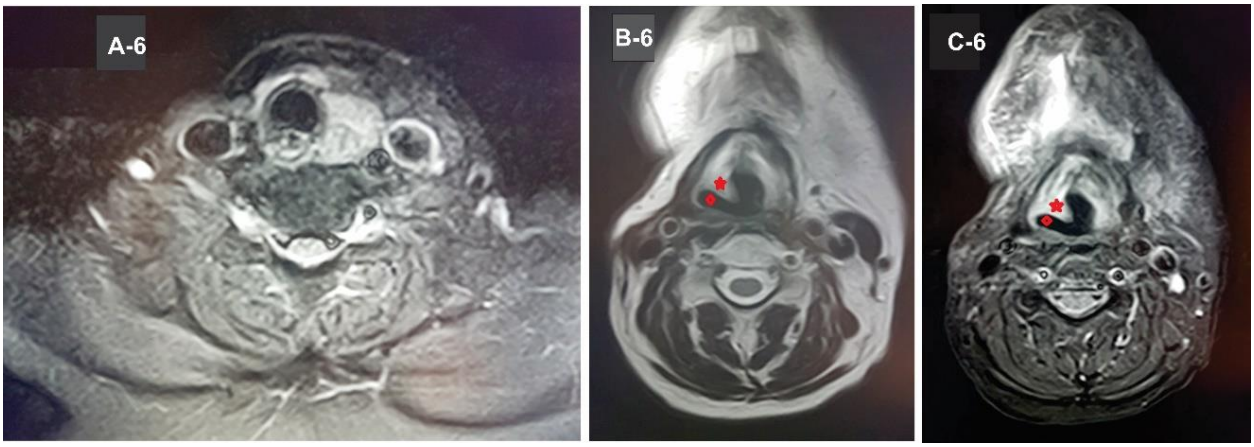

Figure-7: MRI images of a patient who has past history of removal of the right lobe of the thyroid

(A-6) which is axial STIR image at the level of the thyroid gland) with a surgical sequela of injury to the right recurrent laryngeal nerve. The finding is evident as sail sign in the image (B-6) which is axial T2 at the level of true cords and image (C-6) which is axial STIR at the level of true cords; these images show a paralysis of the right vocal cord with a medial deviation of its posterior aspect indicated by a star, and air distended ipsilateral laryngeal ventricle indicated by a diamond

DISCUSSION

VCP should not in itself be considered a primary diagnosis but prompt the radiologist to search for a more serious cause[12,13] along the course of recurrent laryngeal nerve (RCLN). The fast-imaging time of approximately 10 seconds for Computed Tomography (CT) makes it the best possible modality for the evaluation of vocal cords, especially since it negates motion artefacts like those of swallowing and breathing[14]. For best imaging of vocal cords, patients are asked to either breath hold, breathe quietly or perform a modified Valsalva maneuver[15]. In our department, we prefer quiet breathing as vocal cords tend to be in their neutral position during this manoeuvre. This is also the overall preferred method described in the literature for the evaluation of VCP[5]. Images are acquired in a multiplanar fashion with thin

slice sections[16], in our department. 2 mm axial sections are obtained to achieve good quality coronal and sagittal reformat sections of vocal cords. Of these axial images are acquired parallel to the vocal cords as they eliminate the pitfalls of oblique images.

In our study common causes of paralysis recognized included mediastinal tumours including bronchial and oesophageal, cardiomegaly, aortic aneurysm, aorticopulmonary window enlarged lymph node, thyroid malignancies, post thyroidectomy status, trauma to neck with fracture of thyroid or arytenoid cartilage, skull base tumour, brainstem infarct and demyelinating disease involving the brainstem. Mediastinal tumours, notably bronchial were the commonest cause of all which was also seen in the study of Ramadan *et al*[17] though we did not encounter skull base tumours as frequently as their study. In 1 patient true VCP occurred because of long-term overinflated endotracheal tube. This cause has been well-established in literature.[18,19] One patient had dislocated cartilage causing compression of RCLN against the thyroid cartilage at the level of true cords; this cause has also been described in the literature[20]. Establishing an early diagnosis reduces the risks of complications in such patients.[21] Benign causes predominated in younger patients while malignant causes were more frequently encountered in older patients.

Our study showed left vocal cord abnormality to be more frequent than right (46.5% vs 41.9%) which may be attributed to a longer course of left RCLN.[22,23] Similar results were seen in the study of Malhotra *et al*[7] and Glazer *et al*[24]. Bilateral vocal cord involvement was only seen in 5 patients, 2 of which had brainstem pathology and 3 of which had mimics of VCP including swallowing and adjacent fibrosis. Involvement of RCLN was more frequent compared to vagus which was identified in only 2 patients. This result was similar to the study of Chin *et al.*[25]

Of the 7 cross-sectional images of signs of palsy mentioned in the literature, we were able to identify all in a retrospective review. The most frequent of these signs was medial rotation and thickening of the aryepiglottic fold followed by ipsilateral laryngeal ventricle dilatation which was similar to the results of studies of Chin *et al*, Pandey et al and Malhotra et al. Two other frequent signs were ipsilateral pyriform sinus dilatation and sail sign. These former signs were frequently observed in studies of Chin et al and Malhotra et al however sail sign was not as commonly seen as in our study. The rest of the signs were infrequently observed (1 patient each). The flattened subglottic arch seen in 1 of the patients was best demonstrated in a coronal plane which was similar to the observation of Chin et al and Malhotra *et al*. We found a lack of awareness of cross-sectional signs of paralysis as the most common cause of missed diagnosis. Among patients diagnosed to have VCP on cross-sectional imaging, there was a frequent trend of not vigilantly searching for a cause of palsy. This was more frequently seen due to the failure of correlation of pathology diagnosed along the expected course of vagus and RCLN by reporting radiologists thus further stressing the importance of anatomy recall.[26] Lastly 8 patients were falsely labelled VCP as reporting radiologist was not familiar with mimics. In our study, technical factors were the most common attributed mimics including oblique imaging, tilted patients and swallowing which have also been discussed in the study of Christina *et al.*[5] The misinterpretation can be avoided by making certain cricoarytenoid joints covered in the same axial or oblique axial section during imaging and patient is instructed to not swallow during the brief time of examination. 2 patients had regional infiltrative malignancies involving vocal cord. In such cases, recognition of indirect signs, for example, enhancing abnormal soft tissue, loss of fat planes, lymphadenopathy and lesions of bone raises the suspicion of another diagnosis of soft tissue tumour mimicking a medially deviated cord.

Our study sample size was small due to which we were unable to establish significant relationships from data. Moreover, no prior study has been conducted to identify the frequency of missed vocal cord palsy diagnosis, frequency of missed cause of palsy when confident diagnosis was made or frequency of misdiagnosis due to failure to differentiate from mimics. Hence our pilot study lacked a theoretical foundation on which we could base our study or provide a direct comparison. Future studies with a larger study population and further research on this topic will help overcome these constraints.

AUTHORS' CONTRIBUTION

MM: Methodology, validation, formal analysis, investigation, data curation, writing – original draft, visualization. SG: Conceptualization, methodology, investigation, editing. BYF: Editing, supervision.

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