

Diagnostic Accuracy of Computed Tomography in Detection of Cartilage Invasion in Laryngeal Carcinoma Taking Histopathology as Gold Standard

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Author's Contribution

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ABSTRACT

Objective: To determine the diagnostic accuracy of contrast enhanced computed tomography (CECT) of neck in detecting the neoplastic invasion of the laryngeal cartilages among patients with clinically suspected laryngeal carcinoma taking histopathology as gold standard.

Methodology: This cross-sectional study was department of Radiology, Civil Hospital, Karachi from April to October 2018, on the 141 clinically suspected of laryngeal cancer patients of either age and gender. CECT of neck was performed in supine position and parameters were analyzed. Subsequently the patient who were referred to biopsy and histopathological results were followed and recorded and diagnostic accuracy of contrast enhanced CT was analyzed taking histopathology as gold standard.

Results: There were 67.4% male and 32.6% female patients. Mean age was 56.85 ± 9.57 years. Mean symptoms duration was 7.84 ± 2.30 weeks. Out of all, 58.2% cases were diagnosed with laryngeal cartilage invasion in laryngeal carcinoma by CT scan and 60.3% cases by histopathology. Sensitivity, Specificity, PPV, NPV and accuracy were 90.2%, 81.4%, 87.1%, 85.7%, and 86.5% respectively.

Conclusion: Computed Tomography is a precise and non-invasive imaging method for the staging of laryngeal with high sensitivity, although has relatively less specificity.

Keywords: Diagnostic Accuracy, CECT, Neck, Neoplastic Invasion, Laryngeal Cartilages, Carcinoma, Histopathology

Introduction

The laryngeal carcinoma is among the most prevalent malignancies of the head and neck region, involving 30–40% of head and neck malignancies and representing the most common carcinoma in the otolaryngology.¹ It is predominantly squamous cell carcinoma (SCC) and represents a significant health burden throughout the world, with the tumor subsite heterogeneity encompassing supraglottic, glottic, and subglottic forms that considerably impacts the clinical behavior and consequences.² Basis on the global estimations, the age-standardized incidence rate of laryngeal cancer stands at 2.0 per 100,000 globally, with the Caribbean and Central and Eastern Europe recording the highest regional ratios.³ The most common etiological factors include use of tobacco and alcohol, which carry a synergistic effect; substantial consumption of both agents has been shown to enhance head and neck SCC

risk as much as 40-fold.⁴ However the precise preoperative staging is central to the management of laryngeal malignancy, as it directly determines whether a patient undergoes organ-preserving treatment or radical surgeries. Additionally, the cartilage infiltration is the specifically decisive factor in selecting treatment method, and according to the 8th edition of the UICC TNM classification, invasion of the laryngeal cartilage upstages the primary tumour to T4a, that usually qualifies cases for total laryngectomy by the radiotherapy postoperatively.⁵

According to the American Joint Committee guidelines on Cancer staging, the minor thyroid cartilage erosion is classified as T3, although the invasion through the thyroid cartilage is categorized as T4.⁶ Subsequently the discrepancy carries profound therapeutic

implications, as understating a T4a tumor as cT3 could misallocate the therapeutic method toward organ-preserving approaches less likely to succeed durable control, while over staging a T3 as cT4a might unreasonably push the cases toward total laryngectomy and its linked to the morbidity.⁷

However, the CT is the most extensively employed preoperative imaging modality in the estimation of laryngeal malignancy. The contrast-enhanced CT (CECT), in combination with direct laryngoscopy, supports the clinical stage determination and guides the choice of management options by evaluating the depth of the invasion of tumor and its association to surrounding structures.⁸ Though, its diagnostic performance remains a subject of ongoing investigation.

On CECT, it often remains challenging to differentiate inflammation and edema from invasion of the true cartilage, and the specificity of CT may be as low as 70% depends on the criteria of the employed imaging.⁶ Moreover, the significant proportion of patients who are presented as T4 on CT may be down staged upon histopathological review, with approximately 47% of cases showing discordance between CT findings and the findings of pathology in certain series.⁹ Whereas histopathological examination is considered the gold standard for the detection of laryngeal lesions for identifying rare histological variants that may influence treatment strategies,¹⁰ though, it is an invasive procedure and may associated with local complications including pain, bleeding, may airway compromise and is not readily available especially in low-resource settings due to limited pathology infrastructure and expertise. Hence the preoperative imaging remains essential for optimal treatment planning. However, given the wide variation in reported CT accuracy across institutions, and the critical clinical consequences of both over- and understating, there remains a need to evaluate the diagnostic accuracy of CT in detecting laryngeal cartilage invasion against histopathological findings as the reference standard. The present study was therefore designed to determine the sensitivity, specificity, and overall diagnostic accuracy of CT in identifying laryngeal cartilage invasion among cases with laryngeal carcinoma, using histopathology as the gold standard.

Methodology

This cross-sectional study was department of Radiology, Civil Hospital, Karachi from April to October 2018. The laryngeal carcinoma is among the most prevalent malignancies of the head and neck region, involving 30–40% of head and neck malignancies and representing the most common carcinoma in the otolaryngology.¹ It is predominantly squamous cell carcinoma (SCC) and represents a significant health burden throughout the

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Results

Total 141 patients were studied, with overall mean age of 56.85 ± 9.57 years, mean durations of symptoms was 7.84 ± 2.30 weeks and overall mean number of smoking pack years was 7.51 ± 1.72 years. Out of all patients, 67.4% were male and 32.6% were females. Table I

Table: 1. Descriptive statistics of bassline variables n=141		
Variables		Statistics
Mean age of patients		56.85 $\pm$ 9.57 years
Mean symptoms duration		7.84 $\pm$ 2.30 weeks
Mean smoking duration		7.51 $\pm$ 1.72 years
Gender	Male	95(67.4%)
	Female	46(32.6%)

There were 58.2% cases diagnosed as laryngeal carcinoma by CT scan. However, the histopathological results showed 60.3% laryngeal cartilage invasion in laryngeal carcinoma cases. Figure 1

Diagnostic accuracy of CT scan for the detection of laryngeal carcinoma taking histopathology as gold standard were calculated, where 74 patients were true positive, correctly diagnosed and 48 patients were true negative, correctly diagnosed. However, the sensitivity, specificity, PPV, NPV and accuracy were 90.2%, 81.4%, 87.1%, 85.7%, and 86.5% respectively. Table II

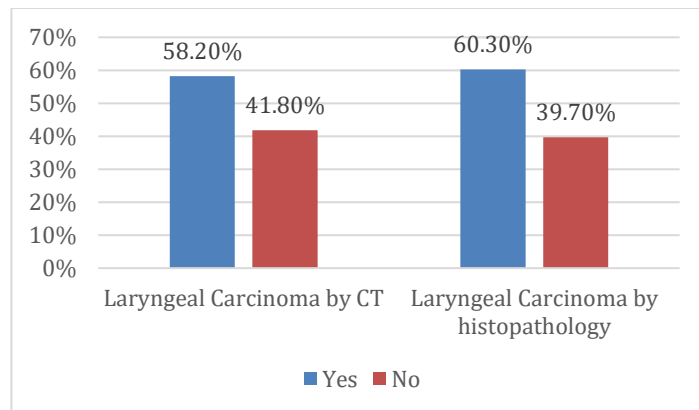


Figure 1. Frequency distribution of laryngeal cartilage invasion in laryngeal carcinoma diagnosed by histopathology. (n=141)

Table II: Diagnostic accuracy of CT scan in diagnosis of laryngeal cartilage invasion taken histopathology as gold standard. (n=141)				
CT SCAN	HISTOPATHOLOGY			P-Value
	Yes	No	TOTAL	
Yes	74(90.2)	8(9.8)	82	0.000*
No	11(18.6)	48(81.4)	59	
Total	85	56	141	
Sensitivity	Specificity	PPV	NPV	Accuracy
90.2%	81.4%	87.1%	85.7%	86.5%

However, specifically among males (n=95), CT scan demonstrated a sensitivity of 86.3%, specificity of 77.3%, PPV of 81.5%, NPV of 82.9%, and an overall accuracy of 82.1% in diagnosing laryngeal cartilage invasion in laryngeal carcinoma, with a statistically significant result (p=0.000), while in female (n=46), CT scan performed considerably better, with higher sensitivity of 96.8%, specificity of 93.3%, PPV of 96.8%, NPV of 93.3%, and an overall accuracy of 95.6%, also statistically significant (p=0.000), as presented in Table III & IV.

Table III: Diagnostic accuracy of CT scan in diagnosis of laryngeal cartilage invasion taken histopathology as gold standard for males. (n=95)				
CT SCAN	HISTOPATHOLOGY			P-Value
	Yes	No	TOTAL	
Yes	44(86.3)	7(13.7)	51	0.000*
No	10(22.7)	34(77.3)	44	
Total	54	41	95	
Sensitivity	Specificity	PPV	NPV	Accuracy
				82.1%

Table IV: Diagnostic accuracy of CT scan in diagnosis of laryngeal cartilage invasion taken histopathology as gold standard for females. (n=95)

CT SCAN	HISTOPATHOLOGY			P-Value
	Yes	No	TOTAL	
Yes	30(96.8)	1(3.2)	31	0.000*
No	1(6.7)	14(93.3)	15	
Total	31	15	46	
Sensitivity	Specificity	PPV	NPV	Accuracy
				95.6%

Discussion

The CT is widely utilized to evaluate the cartilage invasion in laryngeal carcinoma, yet its diagnostic accuracy remains variable across studies and is often overestimated compared with histopathology. This study was conducted on 141 patients, estimates the diagnostic performance of CT in detecting cartilage invasion in laryngeal carcinoma, using histopathology as the reference standard with overall mean age of 56.85 ± 9.57 years and male predominance 67.4%. Consistently Montenegro C et al¹¹ reported that the average age of patients was 69 years, with majority of males 93.2% and 6.8% females. Furthermore, Adeel M et al¹² also reported that a median age of 62 years (62.60 years), comprising 91% males and 9% females, with 62% identified as smokers. In this study also, a significant part of males were smokers. Overall significant male predominance in the studies may be justified by the higher prevalence of risk factors specifically smoking among males, along with higher occupational exposures and health-seeking patterns that raise the likelihood of diagnosis of laryngeal cancer among males compared to females.

In this study 58.2% cases were diagnosed by CT scan, while the histopathological results showed 60.3% laryngeal cartilage invasion in laryngeal carcinoma cases. It aligns to this series Hernandez AK et al¹³ reported that the thyroid cartilage invasion was identified among 63.4% of patients on CT scans and in 58.7% on final histopathological assessment. On the other hand, Weselik M et al¹⁴ reported that the CT imaging showed (61.5%) of pathologically confirmed thyroid cartilage invasion and detected only 2 out of 9 cases (22%) of extra-laryngeal spread, while according to histopathological assessment, thyroid cartilage invasion was found in 47.6% patients, whereas cricoid and arytenoid cartilage involvement were each noted in 4.7% of the cases. Overall CT imaging technique found closely aligned with the histopathological findings with a small difference, representing a strong correlation in the detection of thyroid cartilage invasion among patients.

Objectively this study showed sensitivity, specificity, PPV, NPV and accuracy were 90.2%, 81.4%, 87.1%, 85.7%, and 86.5% respectively of CT scan for the detection of laryngeal carcinoma taking histopathology as gold standard. This pattern aligns to the study by Manouchehri K et al¹⁵ where CT showed a sensitivity of 80.9% and specificity of 62.2% in identifying the cartilage invasion against post-operative histopathology as the gold standard, with PPV 78.5% and NPV 65.7%. However, Thurnheer SE et al¹⁶ conducted the study for diagnostic accuracy of CT and MRI, where CT showed sensitivity 77.1% and higher specificity 86.7% in the detection of cartilage invasion. In contrast the Hartl DM

et al¹⁷ observed that the CT showed very limited diagnostic utility in accurately predicting cartilage invasion among patients representing with early to mid-stage laryngeal lesions, with notably low sensitivity 10.5% and high specificity of 94%. However, the inconsistency may be due to several factors, like variations in CT scanner technology because, protocols of imaging, and slice thickness across institutions significantly influence diagnostic performance or may be differences in radiologist experience and the specific imaging criteria used to define cartilage invasion. On the hand a systemic review demonstrated consistent findings as studies examining PPV from 44% to 80% and NPV from 85% to 100%, of CT in the diagnosis of thyroid cartilage invasion, indicating CT represents a reasonably reliable imaging modality for the preoperative assessment of laryngeal cartilage invasion, particularly with respect to thyroid cartilage invasion.

Additionally, our findings were also supported by the Koopmann et al¹⁸ where MDCT demonstrated a PPV of 76%, NPV of 69%, specificity of 89%, and sensitivity of 46% for thyroid cartilage invasion diagnosis, with significant correlation between radiological and histological findings ($p < 0.05$), encouraging the value of preoperative CT as an important tool in detecting neoplastic laryngeal cartilage invasion among patients with laryngeal carcinoma. Moreover, Wojtera B et al¹⁹ also supported our findings as they observed that the CT imaging produces its highest diagnostic accuracy when conducted within 14 days before surgery, with the modality representing a sensitivity of 68.8%, 60.3% specificity, 65.6% PPV, and 63.8% NPV for the detection of laryngeal cartilage invasion, among laryngeal cancer patients. As well as Pietragalla M et al²⁰ also found consistent findings. Overall most of the studies suggested the CT as more reliable in confirming the presence of cartilage invasion, making it very useful modality, while not definitive preoperative staging tool that may require supplementation with MRI or histopathological correlation for conclusive identification. Additionally, the inconsistency in CT scanner technology, thickness imaging slice, protocols of the contrast enhancement and inter-radiologist interpretation may have influenced the diagnostic accuracy among patients. Hence future comparative studies combining both CT and MRI, and other potentially emerging modalities like dual-energy CT, FDG-PET, and CT-based radiomics, are suggested to determine the most accurate and cost-effective preoperative staging approach for laryngeal cartilage invasion among patients with laryngeal cancer.

Conclusion

CT revealed the moderate sensitivity and high specificity for identifying cartilage invasion in laryngeal carcinoma, with overall good PPV while lower NPV, making it a reliable tool for detecting the invasion but less reliable for excluding it. Hence, CT-based staging should be interpreted carefully, and high-risk or

confusing cases may benefit from complementary modalities such as MRI or histopathological confirmation. The combination of CT with targeted biopsy significantly improves the diagnostic reliability for cartilage invasion in laryngeal carcinoma, as histopathology supports confirm equivocal imaging findings and reduces errors of staging.

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