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Review

Radiological Characteristics, Imaging Techniques and Staging of Lung Cancer

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Abstract

Lung cancer is among the most common cancers worldwide accounting to significant morbidity and mortality. Patients suspected of having lung cancer undergo various diagnostic procedures. Chest X-ray, positron emission tomography, computed tomography and magnetic resonance imaging are used for the diagnosis although combination of computed tomography and positron emission tomography are considered to be more effective and reliable imaging techniques. Lung cancer staging framework provides with better information of the disease and guides in planning treatment modalities. The purpose of this research is to review the available information about the radiological characteristics, imaging techniques and staging of lung cancer. The lung staging has three salient characteristics, tumour, node and metastasis also staging play a critical role in diagnosis and treatment plan. Combination of computed tomography and positron emission tomography undoubtedly improve the mediastinum nodal stage and reduce the number of ineffective interventions thus considered the most productive imaging method. Complete staging should be performed along with the computed tomography in lung cancer patients as a considerable volume growth, a measure of malignancy, has been demonstrated to positively connect with a minimum diameter rise over time. Quality treatment depends on the accurate staging among lung cancer patients. The significance of radiological characteristics, staging and imaging techniques of lung cancer is highlighted in literature through various studies and research although more clinical trials in future can be beneficial.

Keywords: *stage, lung, cancer, image, characteristic*

Introduction

With an estimated two million diagnoses and 1.8 million deaths, lung cancer is the primary cause of cancer incidence and mortality worldwide (1). Lung neoplasms are the second most frequent cancer diagnosis in both men and women after prostate and breast cancer, respectively. Lung cancer incidence is rising internationally due to increased tobacco access and industrialization in emerging countries. The age of diagnosis is approximately 70 years. Although women may be more vulnerable due to larger percentages of epidermal growth factor receptor mutations and the effects of oestrogen, men are twice as likely to be diagnosed with lung cancer (1). Smoking marijuana, electronic cigarettes, tobacco products, and being infected with human immunodeficiency virus and tuberculosis have all been linked to an increased risk of lung cancer. In addition, occupational factors such as asbestos and environmental exposures like air pollution and arsenic may increase the risk of lung cancer (1, 2).

Small cell lung cancer, which has neuroendocrine characteristics and a poor prognosis, and non-small cell lung cancer, which accounts for 70–80% of cases, are divided into different categories. While small cell lung cancer was typically divided into limited and severe disease, the use of the tumour, node and metastasis staging approach for small cell lung cancer is advised. Non-small cell lung cancer staging is based on the tumour, node and metastasis categorization system (2). The pre-operative staging of lung cancer is determined by imaging investigations. To determine tumour resectability, prevent pointless procedures, and evaluate the patient's prognosis, accurate radiological staging is essential. Additionally, radiological tests and investigations are utilized to assess the tumour's response to therapy (2). Patients with suspected lung cancer undergo tissue diagnosis, a thorough staging procedure that includes a look at any metastases, and a functional patient evaluation as part of the diagnostic process. Sputum cytology, thoracentesis, accessible lymph node biopsy, bronchoscopy, transthoracic needle aspiration, video-assisted thoracoscopy, or thoracotomy can all be used to get a histologic diagnosis. The patient's medical history, physical examination, laboratory testing, chest computed tomography (CT) scan, positron emission tomography (PET) scan, and tissue confirmation of mediastinal involvement are all used in the initial evaluation of metastatic disease. Depending on the clinical presentation, further testing for metastases may be necessary. The type and stage of the tumour are key factors in treatment and prognosis (3).

The detection and staging of lung cancer are still made possible by non-invasive imaging methods. A significant, innovative, and precise technique in the radiologist's toolbox is PET scan with fluorodeoxyglucose imaging for lung cancer. The selection of patients for curative lung cancer surgery is largely influenced by CT scanning, magnetic resonance imaging, and PET scan, resulting in fewer needless thoracotomies. The selection of the most appropriate invasive and surgical techniques is also guided by the imaging modalities (4). The purpose of this research is to review the available information about the radiological characteristics, imaging techniques and staging of lung cancer.

Methodology

This study is based on a comprehensive literature search conducted on June 25, 2022, in the Medline and Cochrane databases, utilizing the medical topic headings (MeSH) and a combination of all available related terms, according to the database. To prevent missing any possible research, a manual search for publications was conducted through Google Scholar, using the reference lists of the previously listed papers as a starting point. We looked for valuable information in papers that discussed the information about the radiological characteristics, imaging techniques and staging of lung cancer. There were no restrictions on date, language, participant age, or type of publication.

Discussion

Morphological imaging evaluation using thorax CT or chest X-rays has been a standard part of the evaluation of patients with suspected lung cancer. Additionally, though not diagnostic in nature, 18F-fluorodeoxyglucose, PET scan, bone scintigraphy, and somatostatin receptor scintigraphy although used occasionally have all become more and more common in recent years, giving doctors useful and complementary knowledge on the functional characteristics of lesions. The research of lung cancer has recently benefited considerably by the development of PET scan and CT scan combined imaging, which allows for even better delineation of regions with enhanced tracer uptake. This technique has assisted radiologists in avoiding the technological challenges brought on by the independent PET scan and CT scan exams, which produced significant artifacts. Additionally, by enhancing the

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diagnosis of metastatic disease, directing therapy, and enabling clinical outcomes to be predicted, PET scan and CT scan has been demonstrated to be a reliable technique for the work-up of solitary pulmonary nodules and for lung cancer staging (5, 6).

Imaging techniques and radiological characteristics

Modern spiral and multi-detector technology enables to see the size of the tumour in the surrounding tissues in very detailed 2-dimension or even 3-dimension pictures produced by CT scanners. There are still many instances where CT scan may cast doubt on this, despite the better image quality. Magnetic resonance may be utilized as a problem-solving modality. CT scan has a small but crucial part in defining nodal involvement. It provides a road map of the lymph nodes in the hilum and mediastinum for the surgeon and directs him to the nodes that require a biopsy. Combining CT and PET scan will undoubtedly enhance mediastinum nodal staging and decrease the number of pointless interventional treatments. The most effective imaging method for staging patients with lung cancer is integrated PET and CT scan. It incorporates both morphological and metabolic data. With the advancement of new magnetic resonance technologies, it is now considered a highly promising method for staging lung cancer patients in the future (7).

The initial diagnostic test used in the evaluation of suspected lung cancer is a chest x-ray. Due to its ubiquitous availability, technical viability, minimal danger, and inexpensive cost, it has seen substantial application in the past. More thorough morphological data is needed once a worrisome lesion is found. Even in situ adenocarcinomas, which might manifest as an area of chronic air space illness, can show as central or peripheral masses in the lung. A parenchymal consolidation or super-infection may exist, which could conceal or be the first indication of a potential underlying tumour. The central malignancy may have hilar lymph node enlargement, mediastinal invasion, or bronchial blockage, with partial or whole lung collapse (8, 9). Panunzio stated that complete staging should be done using a CT scan with contrast when the chest X-ray increases the suspicion of malignancy. A considerable volume growth, a measure of malignancy, has been demonstrated to positively connect with a minimum diameter rise over time. The volume of the lesion doubles in response to an increase in diameter of around 26%, and the volume doubles in response to an increase in diameter of a factor of 8. The lesion will be benign often indicative of inflammation or infection especially if the number of nodules doubles in less than seven days. Dimensional criteria are used to evaluate nodal involvement on a CT scan. When the short axis is more than 10 mm, lymph node involvement is traditionally identified (10).

Heuvelmans concluded in his study findings that the majority of tumours in each of the four histopathologic categories had spherical nodule shapes (70.6-95.8%). Without a statistically significant difference between histopathological groups, malignant nodule margins were most frequently lobulated (39.3-45.9%) and spiculated (22.2-35.7%). Adenocarcinomas occurred substantially more frequently (71%) than other forms of malignancies (p=0.004) in the upper lobes, where the majority of tumours (63.5%) were found. Large cell carcinomas had a shorter median volume doubling time (96.8 days, 95% Confidence Interval (CI): 15.8-177.9 days vs. 214.8 days, 95% CI: 186.2-243.4 days [p=0.05]), but adenocarcinomas had a longer median volume doubling time. Other histological subgroups' volume doubling time did not significantly differ from one another (11). Khan reported in his study findings that 34 patients with concurrent idiopathic pulmonary fibrosis were found among the 637 patients with lung cancer (5.3%), and they were all smokers, 41% of cases were diagnosed with squamous cell cancer and 85% were of non-small cell lung cancer. The majority of the tumours were peripheral, in the lower lobes, and exhibited in a honeycomb-like pattern. Even though almost two-thirds of the patients had localized or locally progressed lung cancer, the prognosis for lung cancer therapy was very poor independent of the stage of the tumour or the severity of idiopathic pulmonary fibrosis (12).

Toyokawa revealed in his study findings that in contrast to adenocarcinoma, univariate and multivariate analysis showed a strong correlation between small-cell lung cancer and the presence of notching and the absence of surrounding ground glass opacity, an air bronchogram, a pleural indentation, and spiculation. While surrounding ground glass opacity, air bronchogram, pleural indentation, and spiculation were seen less frequently in patients with small-cell lung cancer of less than 3.0 cm in size compared to those with adenocarcinoma, they were more frequently seen on CT scans of patients with small-cell lung cancer (13). Kunihiro depicted in his findings that squamous cell carcinomas had a maximal cavity wall thickness that was substantially higher than adenocarcinomas (p=0.002). Adenocarcinomas were substantially more likely than squamous cell carcinomas

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to have ground-glass opacity and intratumoural bronchiectasis (p=0.001 and p=0.040, respectively). According to the pathological results, intratumoural bronchiectasis with or without alveolar wall damage significantly altered the relationship between adenocarcinoma and squamous cell carcinoma (p=0.001; odds ratio, 20.35; 95% CI, 3.87-107.10). Squamous cell carcinomas have thicker cavity walls than adenocarcinomas do. Adenocarcinoma is strongly suggested by the presence of intratumoural bronchiectasis and ground-glass opacity (14).

Purandare stated that a wide range of imaging appearances can be seen in the initial tumour. Non-small cell lung cancer can appear as central masses **(Figure 1A)** that invade mediastinal tissues or as peripheral lesions **(Figure 1B)** that penetrate the chest wall. Smooth, lobulated, and irregular and spiculated tumour margins are depicted in **(Figure 1C and 1D)**. They may have core necrosis and cavitation may be uniformly solid **(Figure 2A)**.

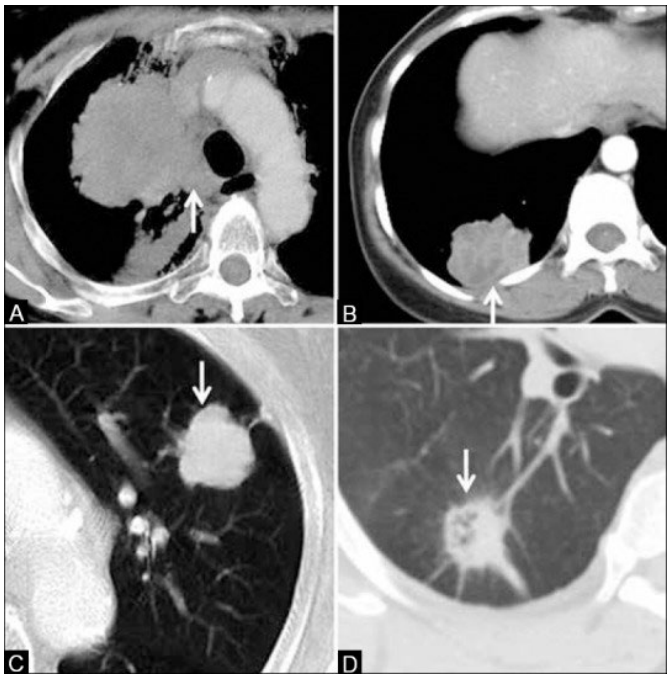

Figure 1: A) Non-small cell lung cancer appears as central masses B) Invasion of mediastinal tissues or peripheral lesions C&D) Smooth, lobulated, and irregular and spiculated tumour margins (15)

Squamous histology tumours are more likely to be centrally located and cavitating. Sometimes the tumour appears as an area of consolidation **(Figure 2B)**, a ground-glass opacity **(Figure 2C)**, or a combination of the two **(Figure 2D)** and mimics an infectious pathology. Adenocarcinoma and its subtypes are more likely to exhibit this look. Bronchoalveolar carcinomas, also known as adenocarcinomas in situ, are now known as mixed density or pure ground-glass nodules and consolidation with air bronchogram **(Figure 2D)**. Regardless of the suspected lung cancer's imaging appearance, a bronchoscopic or image-guided biopsy is required to get a tissue diagnosis (15).

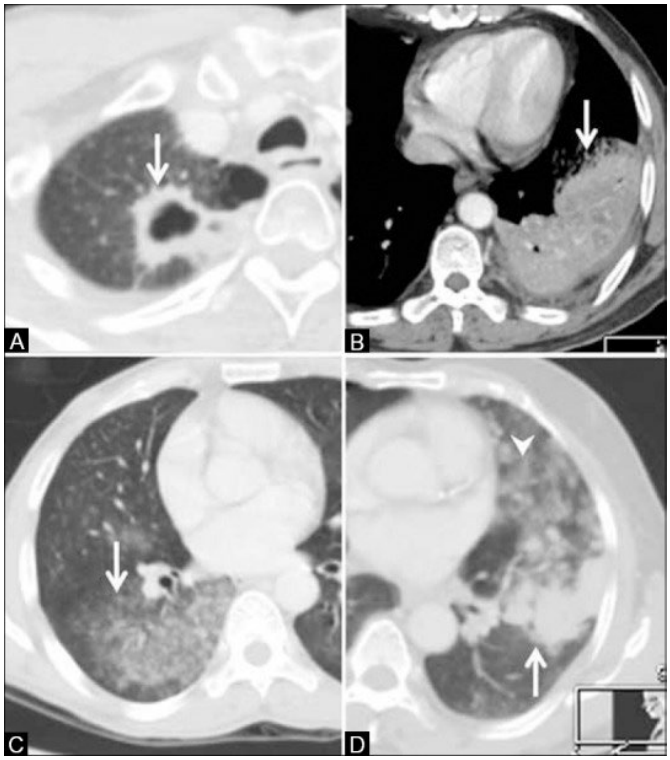

Figure 2: A) Uniformly solid core necrosis and cavitation B) Consolidated tumour C) Ground-glass opacity observed D) Mixed density or pure ground-glass nodules and consolidation with air bronchogram (15)

Staging of lung cancer

Cancer staging methods offer a uniform framework to describe the spread of a tumour so that homogeneous patient groups can be examined and discussed by various sources. The lung cancer staging system organizes treatment plans for physicians and gives patients relevant prognostic information. The seventh widely used non-small cell lung cancer staging system, which was created by the International Association for the Study of Lung Cancer Lung Cancer Staging Project, is the first non-small cell lung cancer staging system to be created from a global patient database and to be both internally and externally validated to significantly stratify patients based on survival outcomes. Current 5-year survival estimates for non-small cell lung cancer range from 73% for stage IA cancer to 13% for stage IV disease based on these tumour, node and metastasis categories. Following tumour histologic grade, patient sex, age, and performance status, tumour, node and metastasis stage

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continues to be the most crucial prognostic indicator in predicting recurrence rates and survival durations (16). Tanoue stated that staging refers to defining the severity of malignant disease. The best care for every patient with lung cancer depends on accurate staging. Better staging yields superior results. Accurate staging requires a solid understanding of the three elements of anatomic staging—tumour, node, and metastasis. Although prognosis is used to categorize stages, patient traits, tumour-specific genetic and immunologic characteristics, and environmental factors all affect survival. It can be difficult to define lung cancer with many pulmonary sites of illness. The tumour component, which has five categories ranging from T0 to T4, defines the size of the primary tumour, the extent of nodal involvement in the thoracic and supraclavicular areas is described by the node component while the level of metastatic involvement is described by the metastasis component (17).

Lim stated that the 8th edition for staging and tumour, node and metastasis classification a new category for metastatic types and defines tumour size is created. Additionally, it further revalidates nodal staging and affirms the prognostic importance. This contributes to the development of a more reliable staging system to ensure consistent data gathering, which in turn influences prognostic classification, treatment choices, and future data collection for research. There are various characteristics that will need additional consideration for the radiologists working on the clinical staging of lung cancer. The most critical are consistency and precision in reporting the tumour size, especially for subsolid nodules because every centimetre now contributes to a larger tumour. Documenting the implicated nodal stations may aid future research on prognostication even while the node staging is unaltered. Quantifying the extra thoracic metastases is increasingly crucial for metastasis staging. It is crucial for physicians and radiologists to be aware of the new staging criteria in order to get ready for the new staging system's international implementation. The new staging system is anticipated to have a positive impact on the management of patients with lung cancer (18). The importance of imaging techniques and staging regarding the aspect of lung cancer is well highlighted in literature by various authors and studies also the radiological characteristics of the disease are well-defined. Although more clinical trials in future can be beneficial to support the imaging features and designing treatment strategies.

Conclusion:

Radiologists play a vital role in the multidisciplinary treatment of patients with lung cancer. Understanding the concepts of staging, the clinical relevance of various radiological features, and their influence are of prime importance in planning treatment strategies in addition to accurately defining the disease's radiological extent and severity.

Disclosure

Statement

The authors declare no conflict of interest.

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Ethical consideration

Non-applicable.

Data availability

Data that support the findings of this study are embedded within the manuscript.

Authors' contribution

All authors contributed equally to the drafting, writing, sourcing, article screening and final proofreading of the manuscript.

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