Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/bwr96a56

ASSESSING THE PRECISION OF CONTRAST-ENHANCED CT SCANS IN DIAGNOSING BRONCHOGENIC CARCINOMA USING HISTOPATHOLOGY AS THE REFERENCE CRITERION

Hadia Faisal[1*], Raisa Shahzadi[2], Aqsa Ayesha Masood[3], Ahmad Mehmood[4], Hassan Sadiq[5], Haroon Amin[6]

[1*]Department of Radiography and Imaging Technology, College of Rehabilitation Sciences, Government College University Faisalabad, Pakistan.
[2]Department of Medical Imaging Technology, The University of Lahore, Pakistan
[3]Postgraduate Trainee, Children Hospital Lahore, Punjab, Pakistan
[4]Department of Medical Imaging Technology, The Superior University, Lahore, Pakistan
[5]Department of Radiography and Imaging Technology, College of Rehabilitation Sciences, Government College University Faisalabad, Pakistan.
[6]Department of Allied Health Sciences, College of Rehabilitation Sciences, Government College University Faisalabad, Pakistan

***Corresponding Author:** Hadia Faisal
*****Email Address: hadiafaisal29@gmail.com

ABSTRACT

Background: Bronchogenic carcinoma is still a complicated, multifaceted illness with a variety of presentations determined by histological subtypes, diagnostic methods, and demographic factors. By using histopathology as the reference standard, the objective of this investigation is to thoroughly assess the efficacy of contrast-enhanced CT (CECT) scans in the identification of bronchogenic cancer.

Method: A group of patients between the ages of 20 and 80 who had been diagnosed withor were suspected of having bronchogenic carcinoma undertook a thorough analysis that looked at factors like gender distribution, age-related trends, connections with cigarette smoking, and propensities for metastasis across different histological subtypes. Sensitivity,specificity, positive predictive value (PPV), and negative predictive value (NPV) were assessed for diagnostic instruments, CECT, and histology.

Results: The study showed a notable gender disparity, with most patients (65%) being men. The need of individualized approaches is highlighted by the fact that age-related trends varied across histological subtypes. Significant insights were gained from associations between smoking status and different subtypes of lung cancer, which confirmed the association between smoking and some subtypes while challenging preconceived assumptions in others. The need for individualized treatment plans was highlighted by the fact that metastatic tendencies varied among subtypes. With a PPV of 91% and an NPV of 67% for CECT and a PPV of 94% and an NPV of 73% for histopathology, respectively, both tests showed good sensitivity and specificity.

Conclusion: This study provides insights into the roles played by demographic parameters,histological subtypes, and diagnostic techniques in the complex terrain of bronchogenic carcinoma diagnosis. The results highlight how CECT and histology work in tandem to improve the diagnostic process'

precision and dependability. Future study will be guided by restrictions, such as sample size and retrospective analysis, to improve diagnostic approaches and examine rapidly developing technology in the industry.

Keywords: Contrast-enhanced computed tomography, bronchogenic carcinoma, CT Scan

INTRODUCTION

Bronchogenic carcinoma, often known as lung cancer, is a serious problem for public health because to its widespread high prevalence and fatality rates (Gharraf et al., 2020). Bronchogenic carcinoma, accounts for a large portion of the total number of deaths from cancer in both male and female (Herman et al., 1994). Lung cancer early detection and diagnosis are essential for enhancing patient outcomes. For the diagnosis of Bronchogenic carcinoma, contrast-enhanced CT scans have demonstrated to be a very sensitive and specific imaging technique (Javed et al., 2020). In addition to the total mortality rates in the US from breast, colon, along with prostate cancer, this disease takes a terrible toll. Unfortunately, the survival rate for lung cancer is alarmingly low, especially in advanced stages, which emphasizes the urgent need for early detection and accurate diagnosis. (Hollings & Shaw, 2002)

In underdeveloped nations like Pakistan, where there is a dearth of statistics on the disease's prevalence, bronchogenic carcinoma is one of the major causes of mortality (Jemal et al., 2011). Lung cancer puts a heavy burden on healthcare systems and patients due to its high prevalence and dismal survival rates. According to recent statistics, it’s miserable 5-year survival rate is 15% the 4th most prevalent cancer to be diagnosed in France (Hollings & Shaw, 2002). Therefore, this study aims to determine the diagnostic accuracy of contrast-enhanced CT scans in the diagnosis of bronchogenic carcinoma, taking histopathology as the gold standard. The primary risk factor for this cancer is smoking, and screening procedures like chest radiography and sputum cytology can help with initial findings and treatment, thereby increasing cancer survival rates. (Lindeman et al., 2018)

Lung cancer associated with cigarette smoking serving as one of the primary contributors to development. More than 90 percent of all cases of bronchogenic carcinoma are made up of small cell, adeno, squamous cell, and large cell carcinomas (Khaliq et al., 2017). Solitary pulmonary lesions (SPLs) can be classified as benign or malignant which are frequently discovered incidentally during chest imaging, is essential for choosing the most appropriate course of treatment. CT is a crucial technique for assessing SPLs, but further study is required to know well it can identify malignancy (Ur-Rehman et al., 2011). The "Early Lung Cancer Action Project" (ELCAP) seeks to raise the proportion of lung cancer patients who receive an early diagnosis and prolong their overall survival by identifying high-risk individuals and implementing low-dose CT screening (Henschke et al., 1999). As a result of their frequent early detection, peripheral lung tumors have lower treatment success rates (A. M. McWilliams et al., 2006). The current method of routinely undergoing serial CT follow-up on all indeterminate nodules is neither efficient nor cost- effective, and it could exposing patients to unneeded radiation. (MacMahon et al., 2017)

The research objective is to evaluate the precision and accuracy of contrast- enhanced CT scans in diagnosing bronchogenic carcinoma, with histopathology serving as the reference criterion. The main objective of this study is to determine whether contrast- enhanced CT scans are capable of accurately identifying different lung cancer stages and subtypes. With more information, we can improve the screening for lung cancer efficiency and diagnosis precision. The results of this study may serve to enhance patient outcomes, enhance diagnostic methods, and ultimately minimize the social impact of lung cancer. The intention of the study is to add to the body of knowledge regarding the diagnostic efficacy of contrast-enhanced CT for lung cancer and assist doctors in making more informed decisions regarding diagnosis and treatment.

MATERIAL AND METHODS

This Cross-sectional and observational study was conducted at Allied Hospital Faisalabad, Government General Hospital, Ghulam Muhammad Abad Faisalabad and Aziz Fatimah Hospital Faisalabad from 28 February, 2023 to 28 July, 2023 and comprised of 60 patients of CT scan.

Data collection instrument:

The data were collected through scan analysis of CT scans that were available manually and on PACS

Sampling technique:

A non-probabilistic sampling technique that relies on convenience rather than random selection.

Inclusion criteria:

Patient age range: 20-80y. Patients with suspected or confirmed bronchogenic carcinoma. Patients who had undergone a contrast-enhanced CT scan as part of their diagnostic workup.
Patients who had experienced histopathology examination as a gold standard for diagnosis.

Exclusion criteria:

The following patients were excluded from the above-mentioned criteria:
Post-traumatic. Patients who had not undergone a contrast-enhanced CT scan as part of their diagnostic workup. Patients who had not experienced histopathology examination for diagnosis. Patients with comorbidities that might have affected the CT scan interpretation (for example, pulmonary fibrosis and chronic obstructive pulmonary disease (COPD).

Data collection procedure:

Identify the study population:

The first step was to identify the patient population that was included in the study. This involved selecting patients from the Allied Hospital Faisalabad, Govt. General Hospital Faisalabad, and Aziz Fatimah Hospital Faisalabad who had been diagnosed with bronchogenic carcinoma and had undergone both contrast-enhanced CT scans and histopathology testing.

Collect data on patient characteristics:

Once the study population had been identified, relevant patient data were collected, such as age, gender, medical history, and other relevant clinical information.

Collect data on CT scan and histopathology results:

The next step was to collect data on the results of each patient's histopathology along with CT scan. This involved reviewing the CT scan images and radiology reports to ascertain the presence or absence of bronchogenic carcinoma. Likewise, the histopathology reports were reviewed to confirm the diagnosis.

Equipment:

160 slice helical CT machine TOSHIBA. PACS, Govt. General Hospital Ghulam Muhammad Abad Faisalabad.
128 slice helical CT machine TOSHIBA. PACS, Allied Hospital Faisalabad.16 slice helical CT machine TOSHIBA. PACS, Aziz Fatimah Hospital Faisalabad.

Data analysis procedure:

The data analysis, made possible by SPSS (Vol. 20), included a pie chart to show gender distribution, a pivot table to give a thorough breakdown of age and subtypes, a cross-tabulation to show patterns in smoking and lung cancer types, Chi-Square Tests to measure significance, and bar charts to show associations between lung cancer types and metastasis.

RESULTS

The accompanying pie chart illustrates the gender distribution of the study population, which consists of 60 patients that were evaluated for bronchogenic cancer.

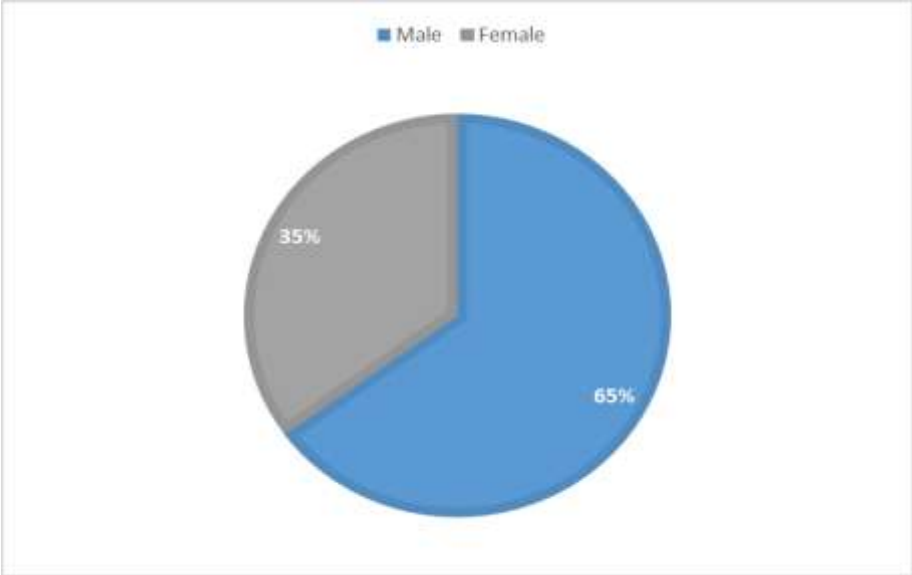

Figure 0.1 Pie chart represents gender distribution According to the pie chart, of the entire cohort of 60 patients,

1. Men 39 (65%)
2. Women 21 (35%).

This gender distribution gives us important demographic information about the make-up of the study cohort, which may have an impact on how we interpret and extrapolate the study's outcomes in light of our knowledge of bronchogenic carcinoma.

Table 0.1 Pivot table represents a comprehensive overview of the distribution of bronchogenic carcinoma cases across different age groups for various histopathological subtypes

Age	**Count of Patients**							
	20-29	**30-39**	**40-49**	**50-59**	**60-69**	**70-79**	**80-89**	**Grand total**
Adenocarcinoma	1	1	5	11	10	3	1	32
Squamous Cell Carcinoma	1	0	3	1	2	0	1	8
SCLC	0	0	0	4	1	1	0	6
Large Cell Carcinoma	0	0	0	0	1	1	0	2
Others	0	0	1	1	1	0	1	4
No evidence	0	3	2	1	1	1	0	8

- With the prevalence of adenocarcinoma, the age range of 50 to 59 years accounted for the highest number of cases (11), followed by that of 60 to 69 years (10 instances).
- Squamous cell carcinoma showed a distinct trend, with most cases clustered in the 40–49 age range (3 cases), then the 60–69 age group (2 cases).
- Large Cell Carcinoma (LCC) was rare, affecting mostly those in the 60-69 age group (1 case).
- Small Cell Lung Carcinoma (SCLC) mostly afflicted people in the 50-59 age group (4 cases).
- Among Others, cases were dispersed across a range of age brackets, with one instance in the 40–49 age group having the highest number.

- The age groups of 30-39 and 40-49 had the most cases in the category of No Evidence, each with three cases.

Table 0.2 Cross-tabulation of lung cancer types and smoking status revealed distinct patterns within each subtype

Lung Cancer Type And Smoking Status Cross tabulation					
		Smoking Status			
Count		**current smoker**	**Former smoker**	**Non smoker**	**Total**
Lung Cancer Type	Adenocarcinoma	24	4	4	32
	Large Cell Carcinoma	1	0	1	2
	No Evidence	2	6	0	8
	Others	1	0	3	4
	SCLC	3	1	2	6
	Squamous Cell Carcinoma	3	1	4	8
Total		34	12	14	60

The majority of the 32 instances of adenocarcinoma (75%) involved current smokers, the proportion of former smokers (12.5%) and non-smokers (12.5%) was lower. One person of the two occurrences of large cell carcinoma in this group was a current smoker, while the other was a nonsmoker.
Despite no particular lung cancer diagnosis, the "No Evidence" category, which consisted of 8 cases, contained both current (25%) and former smokers (75%). 1 current smoker and the other 3 non-smokers made comprised the 4 instances in the "Others" group. One past smoker, one current smoker, and two non-smokers made up the 6 instances of Small Cell Lung Carcinoma (SCLC).
Likewise, the bulk of the 8 cases of squamous cell carcinoma (50%) were not smokers, with one former smoker (12.5%) making up the group of current smokers (37.5%). These data illustrate the complex interplay between smoking status and various lung cancer subtypes, highlighting the significance of customized approaches to diagnosis, prevention, and treatment.

Table 0.3 Chi-Square Tests show a substantial correlation between smoking status and multiple types of lung cancer

	Value	**df**	**Asymptotic Significance (2-sided)**
Pearson Chi-Square	30.418[a]	10	.001
Likelihood Ratio	26.923	10	.003
N of Valid Cases	60		

Chi-Square Tests
a. 15 cells (83.3%) have expected count less than 5. The minimum expected count is .40. The Likelihood Ratio (p =.003) and Pearson Chi-Square (p =.001) tests both demonstrate a statistically significant connection.

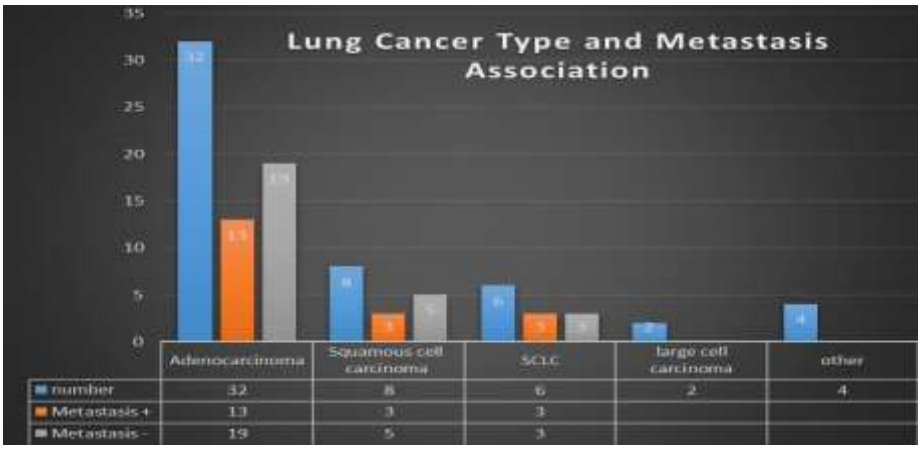

Figure 0.2 Bar chart illustrates the connection between different lung cancer types and metastasis

In the adenocarcinoma group, metastasis was seen in 13 out of 32 cases (+) while it was absent in 19 cases (-). 3 out of the 8 instances of squamous cell carcinoma had metastases (+), whereas the remaining 5 did not (-). 3 of the 6 cases of small cell lung cancer (SCLC) showed metastasis (+), while the other 3 did not (-). Both metastasis (+) and metastasis (-) were absent in large cell carcinoma and other kinds. These findings offer insightful information about how various subtypes of lung cancer behave during metastatic spread.

Table 0.4 Assessing the Precision of Contrast-Enhanced CT Scans in Diagnosing Bronchogenic Carcinoma Using Histopathology as the Reference Criterion

	CECT Positive results	**CECT Negative results**
Histopathology Positive results	45 (TP)*	03 (FN)***
Histopathology Negative results	04 (FP)**	08 (TN)****

The results show that CECT exhibited significant sensitivity, with 45% of patients who tested positive on CECT scans later being confirmed as positive on histopathology. However, an insignificant number of cases (5%), CECT led to positive results that were later revealed to be false positives by histology. In terms of specificity, 67% of patients with negative CECT results had their histology results accurately characterized as negative. The possibility that a positive CECT result will really result in a positive histological finding is known as the positive predictive value (PPV) for CECT, which was 91%.

With 94% of patients who tested positive on histology also producing positive CECT results, histopathology demonstrated great sensitivity. Although histology gave positive results in 8% of the patients, CECT scans later showed the results to be negative.

In terms of specificity, CECT correctly recognized as negative 73% of patients with negative histological data. The probability that a negative histology data will really result in a negative CECT finding is indicated by the histopathology's 73% negative predictive value (NPV).

DISCUSSION

The gender distribution throughout the patient population, aged 20 to 80, is one obvious demographic trait. Men made up 65% of the cohort overall in this study, while women made up the remaining 35%, revealing a sizable gender discrepancy. This disparity between men and women has implications on the overall field of research on bronchogenic cancer. Potential gender-specific differences in risk factors, etiology, and treatment outcomes must be taken into account. This underlines the importance of gender-inclusive clinical and research methods. The age distribution analysis of the various histological

subtypes of bronchogenic carcinoma revealed significant age-related patterns. The age range of adenocarcinoma was broad, with a concentration in the 50–69 age range.

This finding is consistent with the widely accepted theory that adenocarcinoma is a subtype that can evolve over time and is frequently detected in later life stages. Squamous Cell Carcinoma, on the other hand, primarily exhibited in the 40–49 and 60–69 age groups, indicating probable changes in the etiological causes for this particular subtype. The aggressive Small Cell Lung Carcinoma (SCLC) primarily affects people in the 50–59 age range, underscoring the significance of early identification in this age range. Large Cell Carcinoma cases were less common, however they were mostly found in people aged 60 to 69.

The "Others" category displayed cases that were spread out among age groups, showing the group's variety and perhaps including rarer subtypes or unusual presentations. In addition, instances spanning a range of age groups were found in the "No Evidence" category, highlighting the need for evaluation even in the lack of a specific subtype diagnosis.

A significant correlation between smoking status and certain forms of lung cancer was found, which was supported by Chi-Square tests. Adenocarcinoma cases were overwhelmingly smokers (75% of the total), followed by former smokers (12.5%) and non- smokers (12.5%) in decreasing order. This is consistent with the known association between smoking and adenocarcinoma and emphasizes the criticality of smoking cessation programs for those who are at risk. Conversely, the Large Cell Carcinoma group included a non-smoker even when the sample size is modest, disproving the popular assumption that those who have smoked in the past are more inclined to develop lung cancer.

The "No Evidence" category, which included people without a particular lung cancer subtype diagnosis but some of them had a history of smoking, raised intriguing issues about the necessity for ongoing surveillance and potential early treatments. The range of lung cancer subtypes and their relationship with smoking status were best illustrated by the "Others" group. More investigation is required in order to comprehend the factors that resulted in the confirmation of lung carcinoma in this category of non- smokers. The prevalence of current smokers in SCLC and Squamous Cell Carcinoma, which are aggressive lung cancer subtypes that are frequently significantly related with smoking, emphasizes the significance of smoking prevention and cessation initiatives to reduce the risk of these cancers.

The study evaluated the likelihood of metastasis in several lung cancer subtypes. The most frequent subtype of adenocarcinoma displayed varying metastatic tendencies, with some patients exhibiting metastasis and others not. Squamous Cell Carcinoma, the opposite hand, showed a reduced incidence of metastasis, which may indicate a less aggressive metastatic character. The 50% metastatic rate of SCLC, which is known for being aggressive, highlights the importance of early identification and care for this subtype. Notably, no cases of metastasis were seen in Large Cell Carcinoma or other less common subtypes, necessitating additional study to understand these subtypes' features.

Histopathology and contrast-enhanced CT (CECT) are the diagnostic methods used in this study to diagnose bronchogenic cancer. These approaches, each with specific qualities and potential drawbacks, form the basis of clinical practice. A heartening confirmation of the value of both the CECT and histopathology as diagnostic tools is the exceptional sensitivity demonstrated by both in reliably detecting true positive cases. False positives and negatives, however, serve as a reminder of the complexity of clinical diagnosis. A thorough strategy that incorporates both techniques and makes use of additional confirmation where necessary is crucial for reducing diagnostic differences.

In order to better comprehend the dependability of these diagnostic techniques, positive predictive value (PPV) and negative predictive value (NPV) assessments are made. CECT confirms its skill in correctly identifying genuine positive patients with a PPV of 91%, reiterating its function as an important diagnostic tool. Histopathology, on the other hand, has an NPV of 73%, indicating that it is effective in identifying true negative cases and providing certainty that the disease has been ruled out.

Limitations:

This study does have some limitations, though. Given the rarity of some subtypes, the sample size might not accurately reflect the variety of bronchogenic carcinoma presentations. Retrospective data

analysis can also reveal biases and restrictions common to such investigations. Additionally, even though this study highlights the value of CECT and histology, alternative diagnostic techniques and developing technological advancements in the area deserve consideration.

CONCLUSION

This study highlights the major contributions of gender, age, smoking status, and metastatic potential to our knowledge of this intricate illness, illuminating the diverse terrain of bronchogenic carcinoma diagnosis. The complex relationships between these variables highlight the necessity for specialized strategies in clinical practice and research to address the variety of bronchogenic carcinoma presentations.

The diagnostic assessment also emphasizes the complimentary functions of histology and contrast-enhanced CT scan in clinical diagnosis. Their great sensitivity, as well as the evaluation of both positive and negative predictive values (PPV and NPV), improve the accuracy and reliability of diagnostic processes, empowering physicians to make wise judgments about the diagnosis and treatment of patients.

RECOMMENATIONS

To continue understanding the complex features of bronchogenic carcinoma, its risk factors, and diagnostic approaches, additional research projects with larger and more diverse cohorts are necessary.

These restrictions point us in the direction of continued research and the search for more sophisticated strategies, such as investigating the integration of artificial intelligence into diagnostic workflows, to improve our comprehension and control of this complex disease.

Furthermore, conducting thorough comparison studies to evaluate the cost- effectiveness and clinical results of various diagnostic procedures offers a crucial direction for future study, assisting us in making judgments in the pursuit of more effective diagnostic and therapeutic solutions.

Additionally, determining the relationship between diagnostic precision and therapeutic outcomes is crucial because it can provide important information about the efficacy of diagnostic approaches and how they affect patient care and survival rates.

REFERENCES

1. Chen, S., Li, X., Chen, M., Yin, Y., Li, N., & Li, Y. (2016). Limited diagnostic value of Dual-Time-Point 18F-FDG PET/CT imaging for classifying solitary pulmonary nodules in granuloma-endemic regions both at visual and quantitative analyses. European Journal of Radiology, 85(10), 1744–1749.
2. Dabrowska, M., Krenke, R., Korczynski, P., Maskey-Warzechowska, M., Zukowska, M., Kunikowska, J., Orłowski, T., & Chazan, R. (2015). Diagnostic accuracy of contrast-enhanced computed tomography and positron emission tomography with 18-FDG in identifying malignant solitary pulmonary nodules. Medicine (United States), 94(15), 1–7.
3. Davidson, M. R., Gazdar, A. F., & Clarke, B. E. (2013). The pivotal role of pathology in the management of lung cancer. Journal of Thoracic Disease, 5(SUPPL.5).
4. Erasmus, J. J., Connolly, J. E., McAdams, H. P., & Roggli, V. L. (2000). Solitary pulmonary nodules: Part I. Morphologic evaluation for differentiation of benign and malignant lesions. In Radiographics (Vol. 20, Issue 1, pp. 43–58).
5. Faridi, N., & Ahmed, R. (1995). Patho-epidemiology of lung cancer in Karachi.
6. Gao, F., Li, M., Sun, Y., Xiao, L., & Hua, Y. (2017). Diagnostic value of contrast-enhanced CT scans in identifying lung adenocarcinomas manifesting as GGNs (ground glass nodules). Medicine (United States), 96(43), 1–6.
7. Gharraf, H. S., Mehana, S. M., & ElNagar, M. A. (2020). Role of CT in differentiation between subtypes of lung cancer; is it possible? The Egyptian Journal of Bronchology, 14(1).

8. Glazer, H. S., Kaiser, L. R., Anderson, D. J., Molina, P. L., Emami, B., Roper, C. L., & Sagel, S. S. (1989). Indeterminate Mediastinal Invasion in Bronchogenic Carcinoma: CT Evaluation'.
9. Haura, E. B. (2001). Treatment of advanced non-small-cell lung cancer: A review of current randomized clinical trials and an examination of emerging therapies. Cancer Control, 8(4), 326–336.
10. Henschke, C. I., McCauley, D. I., Yankelevitz, D. F., Naidich, D. P., McGuinness, G.,
11. Miettinen, O. S., Libby, D. M., Pasmantier, M. W., Koizumi, J., Altorki, N. K., & Smith, J. P. (1999). Early Lung Cancer Action Project: overall design and findings from baseline screening. Lancet (London, England), 354(9173), 99–105.
12. Herman, S. J., Winton, T. L., Weisbrod, G. L., Towers, M. J., & Mentzer, S. J. (1994). S From the Departments of Radiology. In Radiology (Vol. 190).
13. Hollings, N., & Shaw, P. (2002). Diagnostic imaging of lung cancer. European Respiratory Journal, 19(4), 722–742.
14. Izbicki, J. R., Thetter, O., Karg, O., Kreusser, T., Passlick, B., Trupka, A., Haussinger, K., Woeckel, W., Kenn, R. W., Wilker, D. K., Limmer, J., & Schweiberer, L. (1992). Accuracy of computed tomographic scan and surgical assessment for staging of bronchial carcinoma: A prospective study. Journal of Thoracic and Cardiovascular Surgery, 104(2), 413–420.
15. Javed, F., Rehman, I., & Hasnain, S. (2020). ORIGINAL ARTICLE ACCURACY OF COMPUTED TOMOGRAPHY IN CHARACTERI- ZATION OF PULMONARY LESIONS. 30(December), 246–251.
16. Javed, F., ur Rehman, I., & Hasnain, S. (n.d.). ACCURACY OF COMPUTED TOMOGRAPHY IN CHARACTERI-ZATION OF PULMONARY LESIONS. 30(4), 246–251.
17. Jemal, A., Bray, F., Center, M. M., Ferlay, J., Ward, E., & Forman, D. (2011). Global cancer statistics. CA: A Cancer Journal for Clinicians, 61(2), 69–90.
18. Khaliq, N., Jesrani, A., Mansoor, M. A., Nizamani, W. M., Mahmud, R., & Zaidi, M. H. (2017). Diagnostic Accuracy of Contrast Enhanced Computed Tomography in Detecting Bronchogenic Carcinoma-Experience At Liaquat National Hospital (Vol. 11, Issue 1).
19. Li, F., Sone, S., Abe, H., Macmahon, H., & Doi, K. (2004). Malignant versus benign nodules at CT screening for lung cancer: comparison of thin-section CT findings. Radiology, 233(3), 793–798.
20. Lindeman, N. I., Cagle, P. T., Aisner, D. L., Arcila, M. E., Beasley, M. B., Bernicker, E. H., Colasacco, C., Dacic, S., Hirsch, F. R., Kerr, K., Kwiatkowski, D. J., Ladanyi, M., Nowak, J. A., Sholl, L., Temple-Smolkin, R., Solomon, B., Souter, L. H.,
21. Thunnissen, E., Tsao, M. S., … Yatabe, Y. (2018). Updated Molecular Testing Guideline for the Selection of Lung Cancer Patients for Treatment With Targeted Tyrosine Kinase Inhibitors: Guideline From the College of American Pathologists, the International Association for the Study of Lung Cancer, and the Association for Molecular Pathology. Journal of Molecular Diagnostics, 20(2), 129–159.
22. Luo, S., Li, X., Chen, S., Wang, D., & Tan, Y. (2016). Contrast-Enhanced Chest Computed Tomography (CT) Scan with Low Radiation and Total Iodine Dose for Lung Cancer Detection Using Adaptive Statistical Iterative Reconstruction. Iranian Journal of Radiology, 13(4).
23. MacMahon, H., Austin, J. H. M., Gamsu, G., Herold, C. J., Jett, J. R., Naidich, D. P., Patz,
24. E. F., & Swensen, S. J. (2005). Guidelines for management of small pulmonary nodules detected on CT scans: A statement from the Fleischner Society. In Radiology (Vol. 237, Issue 2, pp. 395–400).
25. MacMahon, H., Naidich, D. P., Goo, J. M., Lee, K. S., Leung, A. N. C., Mayo, J. R., Mehta,
A. C., Ohno, Y., Powell, C. A., Prokop, M., Rubin, G. D., Schaefer-Prokop, C. M., Travis, W. D., Van Schil, P. E., & Bankier, A. A. (2017). Guidelines for management of incidental pulmonary nodules detected on CT images: From the Fleischner Society 2017. In Radiology (Vol. 284, Issue 1, pp. 228–243). Radiological Society of North America Inc.

26. McWilliams, A. M., Mayo, J. R., Ahn, M. I., MacDonald, S. L. S., & Lam, S. C. (2006). Lung Cancer Screening Using Multi-Slice Thin-Section Computed Tomography and Autofluorescence Bronchoscopy. Journal of Thoracic Oncology, 1(1), 61–68.
27. McWilliams, A., & Mayo, J. (2008). Computed tomography-detected noncalcified pulmonary nodules: A review of evidence for significance and management. In Proceedings of the American Thoracic Society (Vol. 5, Issue 9, pp. 900–904).
28. Nomori, H., Watanabe, K., Ohtsuka, T., Naruke, T., Suemasu, K., & Uno, K. (2004). Evaluation of F-18 fluorodeoxyglucose (FDG) PET scanning for pulmonary nodules less than 3 cm in diameter, with special reference to the CT images. Lung Cancer, 45(1), 19–27.
29. Pastorino, U., Bellomi, M., Landoni, C., De Fiori, E., Arnaldi, P., Picchio, M., Pelosi, G., Boyle, P., & Fazio, F. (2003). Early lung-cancer detection with spiral CT and positron emission tomography in heavy smokers: 2-year results. Lancet (London, England), 362(9384), 593–597.
30. Purandare, N. C., & Rangarajan, V. (2015). Imaging of lung cancer: Implications on staging and management. Indian Journal of Radiology and Imaging, 25(2), 109–120.
31. Rami-Porta, R., Bolejack, V., Crowley, J., Ball, D., Kim, J., Lyons, G., Rice, T., Suzuki, K., Thomas, C. F., Travis, W. D., & Wu, Y. L. (2015). The IASLC lung cancer staging project: Proposals for the revisions of the T descriptors in the forthcoming eighth edition of the TNM classification for lung cancer. Journal of Thoracic Oncology, 10(7), 990–1003.
32. Schaefer-Prokop, C., & Prokop, M. (2002). New imaging techniques in the treatment guidelines for lung cancer. European Respiratory Journal, Supplement, 19(35), 71– 83.
33. Shetty, C. M., Lakhkar, B. N., Gangadhar, V. S. S., & Ramachandran, N. R. (2005). Changing pattern of bronchogenic carcinoma: A statistical variation or a reality? Indian Journal of Radiology and Imaging, 15(2), 233–238.
34. Sun, Y., Zhao, W., Kuang, K., Jin, L., Gao, P., Duan, S., Xiao, Y., Liu, J., & Li, M. (2022). Non-contrast and contrast enhanced computed tomography radiomics in preoperative discrimination of lung invasive and non-invasive adenocarcinoma. Frontiers in Medicine, 9(November), 1–10.
35. Swensen, S. J., Jett, J. R., Hartman, T. E., Midthun, D. E., Sloan, J. A., Sykes, A. M., Aughenbaugh, G. L., & Clemens, M. A. (2003). Lung cancer screening with CT: Mayo clinic experience. Radiology, 226(3), 756–761.
36. Ur-Rehman, , Memon, W., Husen, Y., Akhtar, W., Sophie, R., & Baig, M. A. (2011). Accuracy of computed tomography in diagnosing malignancy in solitary pulmonary lesions. In Journal of the Pakistan Medical Association (Vol. 61, Issue 1).
37. Verschakelen, J. A., Bogaert, J., & De Wever, W. (2002). Computed tomography in staging for lung cancer. European Respiratory Journal, Supplement, 19(35), 40–48.