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Computed Tomography Spectrum of Carcinoma Lung: A Case Series A Comprehensive Analysis of Radiological Findings and Metastatic Patterns

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Abstract

Background: Lung cancer remains the premier cause of cancer-related mortality worldwide, necessitating precise diagnostic interventions for effective management. Computed tomography (CT) serves as a cornerstone in the initial detection, anatomical staging, and evaluation of metastatic spread in patients suspected of having bronchogenic carcinoma.

Purpose: This study sought to evaluate the CT imaging spectrum and diverse metastatic patterns of carcinoma lung in patients presenting to a tertiary care facility.

Materials and Methods: A retrospective observational study was conducted involving 23 patients whose CT findings were highly suggestive of primary lung malignancy. Data were extracted from CT scan records spanning from April 2019 to February 2025. The analysis focused on demographic characteristics, specific CT morphological features, and the presence of regional or distant metastatic disease.

Results: The study population showed a clear male predominance (approximately 70–75%) with a mean age of roughly 63 years. The majority of patients were in their sixth and seventh decades of life. CT imaging frequently identified primary lung masses consistent with bronchogenic carcinoma. Metastatic involvement was common and multifaceted, involving the mediastinal and hilar lymph nodes, pleura, and pulmonary parenchyma. Critical vascular involvement was also noted, including superior vena cava (SVC) abutment and thrombosis.

Conclusion: CT imaging is indispensable for identifying primary lung malignancies and characterizing the extent of nodal and distant spread. Recognizing these characteristic imaging patterns is essential for accurate staging and informing management strategies.

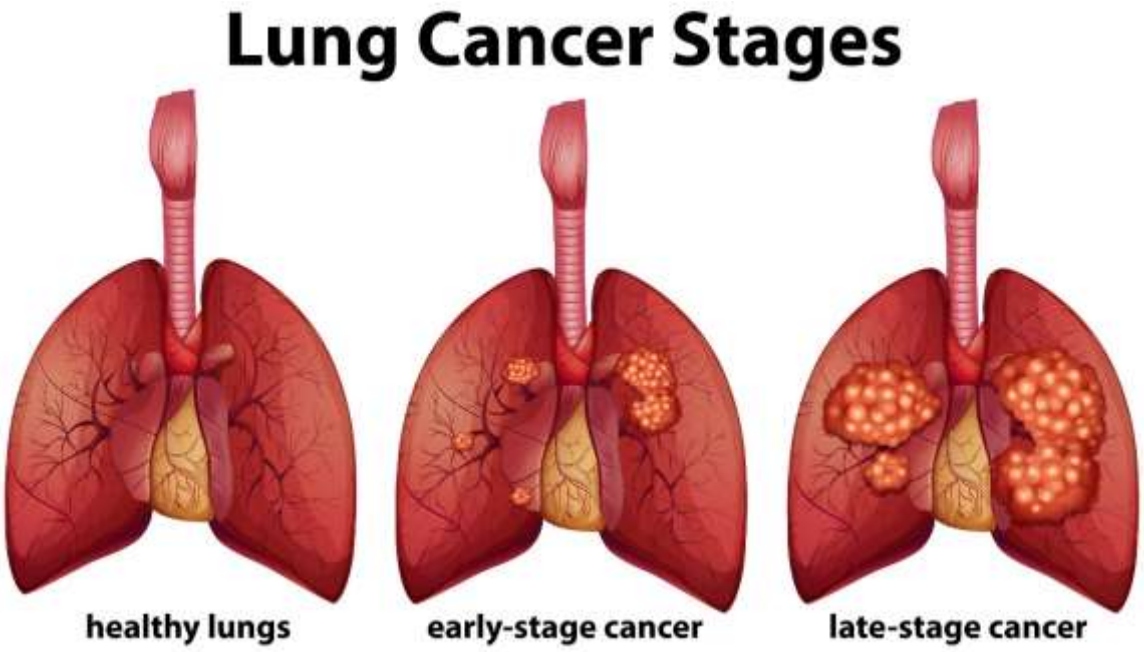
1. Introduction

Lung cancer represents a staggering public health burden, maintaining its status as the leading cause of cancer-related deaths on a global scale. In many clinical settings, particularly within developing regions, patients often present with advanced-stage disease, making the window for curative intervention narrow. Consequently, the imperatives of early diagnosis and highly accurate staging cannot be overstated, as they are the primary determinants for selecting appropriate treatment strategies and forecasting patient prognosis.

Computed tomography (CT) has emerged as the primary and most reliable imaging modality for the comprehensive evaluation of lung malignancies. Its utility lies in its ability to provide high-resolution,

cross-sectional visualizations that allow radiologists to assess:

- **Tumor Size and Morphology:** Detailed assessment of the primary mass.
- **Lymph Node Involvement:** Identification of regional spread to hilar and mediastinal nodes.
- **Mediastinal Invasion:** Evaluation of the tumor's relationship to central structures.
- **Distant Metastasis:** Detection of systemic spread to organs like the adrenal glands.



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Bronchogenic carcinoma constitutes the vast majority of primary lung cancers and frequently presents with nodal and distant metastatic disease at the time of initial diagnosis. This study aims to describe the CT imaging spectrum and associated metastatic patterns observed in a series of patients from a tertiary care hospital.

Materials and Methods

Study Design and Ethical Considerations

This research was structured as a retrospective observational study conducted at a specialized tertiary care center. The primary objective was to analyze the computed tomography (CT) imaging spectrum and identify the various metastatic patterns in patients presenting with clinical suspicion of carcinoma lung. By adopting a retrospective approach, the study utilized existing radiological records and patient data collected over a nearly six-year period, specifically from April 2019 to February 2025.

Study Population and Selection Criteria

The study cohort comprised 23 patients who exhibited CT findings highly suggestive of primary lung malignancy, such as bronchogenic carcinoma. To maintain a rigorous data set, specific inclusion and exclusion criteria were established:

- **Inclusion Criteria:** The study included both adult and adolescent patients who presented with a CT thorax showing features indicative of primary lung carcinoma. A prerequisite for inclusion was the availability of complete CT scan records to ensure a thorough analysis of the disease extent.

- **Exclusion Criteria:** Patients were excluded if their imaging data were incomplete or if the lung masses were determined through further evaluation to be non-neoplastic in nature.

Data Collection and Parameter Analysis

Data were systematically extracted from official CT scan registers and radiology records. The variables analyzed for each patient included demographic characteristics such as age and sex, the specific date of the diagnostic scan, the final CT-based diagnosis, and detailed evidence regarding the presence and location of metastatic disease.

Study Population and Sampling (Lung Cohort)

Patients with a confirmed radiological diagnosis of primary pulmonary malignancies were enrolled in this study. The study population was drawn from patients presenting with clinical indicators such as persistent cough, hemoptysis, unexplained weight loss, or incidental nodules found on screening.

Ethical Compliance and Data Integrity:

- **Informed Consent:** Formal written consent was obtained from all participants prior to the administration of contrast media or radioactive tracers.
- **Medical Responsibility:** The clinical team assumed full medical responsibility for the patients, ensuring strict monitoring for contrast-induced nephropathy or allergic reactions.
- **Data Protection:** Data were extracted from the PACS and electronic medical records with rigorous de-identification protocols. Complete medical responsibility was taken to ensure that the study caused no harm to the integrity of the subjects or the security of their private health information.

The Role of Contrast-Enhanced Computed Tomography (CECT)

While the study utilizes standard CT findings, Contrast-Enhanced Computed Tomography (CECT) is the preferred gold standard in clinical practice for evaluating suspected bronchogenic carcinoma. CECT involves the intravenous administration of iodinated contrast media, which significantly enhances the visualization of vascular structures and the enhancement patterns of soft-tissue masses.

Advantages of CECT in Lung Cancer Imaging:

- **Vascular Mapping:** CECT is superior in demonstrating the relationship between a lung mass and adjacent great vessels. In this study, for instance, it allowed for the identification of superior vena cava (SVC) abutment and the detection of thrombosis in the SVC and right brachiocephalic vein.
- **Lymph Node Characterization:** Contrast helps differentiate between a solid, enhancing lymph node and adjacent non-enhancing structures, which is vital for accurate mediastinal and hilar staging.
- **Differentiation of Masses**: Enhancement patterns can help radiologists distinguish between necrotic components of a tumor and viable neoplastic tissue, providing a clearer picture of the tumor's morphology.
- **Metastatic Detection:** CECT improves the detection of highly vascular metastases, such as those occurring in the adrenal glands, which was a key finding in this patient series.

Statistical Methodology

The collected data were analyzed using descriptive statistics to determine the mean age of the population,

the percentage of male vs. female predominance, and the frequency of specific metastatic sites. This comprehensive radiological review allowed for the identification of characteristic imaging patterns essential for staging and management planning.

4. Results and Data Analysis

Demographic Distribution and Clinical Profile

The demographic profile of the 23 patients included in this case series provides a critical snapshot of the population most vulnerable to lung malignancy within a tertiary care setting. By analyzing age, gender, and the timing of diagnosis, we can better understand the clinical presentation of bronchogenic carcinoma.

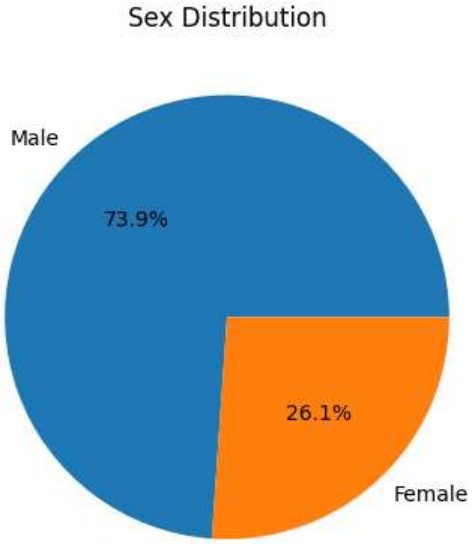
Gender Predominance

A striking feature of this study is the significant male predominance, with approximately 70–75% of the patients being male. Out of the 23 unique cases identified, 17 were male and 6 were female. This distribution is consistent with global oncological literature, which traditionally links higher lung cancer rates in men to historical trends in tobacco consumption and occupational exposure to carcinogens.

In this specific cohort, the male patients ranged from adolescents to the elderly, including cases such as:

- Aniket Unate (17/M): A rare instance of juvenile presentation.
- Devidas Barsagade (77/M): Representing the upper age limit of the male cohort.
- Ghasita Yadav (55/M): A case notable for advanced vascular complications.

The female minority (~26%) included patients like Anusuya Bandewar (33/F) and Shaheda (79/F), demonstrating that while less frequent in this series, the disease spans a wide biological spectrum in women as well.



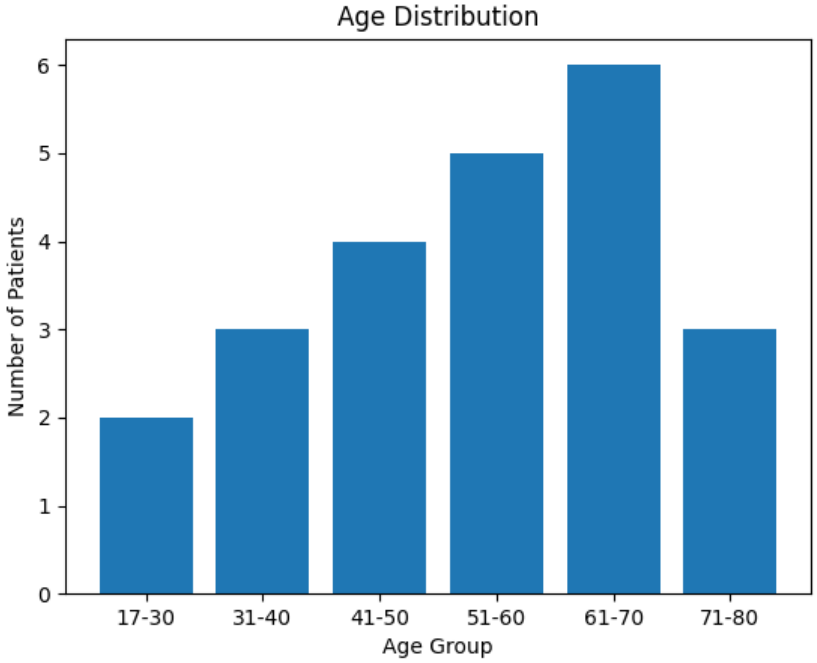
Age Characteristics and Peak Incidence

The age of the study participants ranged from 17 to 79 years. Despite this broad range, the data reveals a high concentration of cases in specific life stages. The mean age of the patients was calculated to be approximately 63 years.

The data shows that the majority of patients belonged to the 6th and 7th decades of life. This peak incidence in the 50s, 60s, and 70s reflects the cumulative nature of genetic mutations and environmental exposures that lead to respiratory malignancies. Specifically, the case list shows a high density of patients aged 60 and above:

- **60-69 Age Group**: Includes patients like Mohd Ayyub (65), Rashid Abdul (62), and Atmaram Nandanwar (67).
- **70-79 Age Group:** Includes Chotelal Patel (75), Ashok Masram (72), and Krushna Rao (70).

The presence of an outlier, a 17-year-old male (Aniket Unate), is particularly significant. While lung cancer is overwhelmingly a disease of the elderly, such cases emphasize the necessity for clinicians to maintain a degree of suspicion even in younger patients presenting with suggestive radiological features.



Temporal Distribution and Diagnostic Trends

The retrospective nature of the study allowed for data collection over a multi-year period, specifically from April 2019 to February 2025. This timeframe is crucial as it encompasses various shifts in diagnostic accessibility. The records indicate that many diagnoses were made in late 2023 and 2024, such as Md Aslam (Oct 2024) and Mohd Harun (Nov 2024).

The diagnostic labels provided in the records consistently identify "Carcinoma Lung" or "Bronchogenic Carcinoma" as the primary findings. The demographic data, when paired with these diagnoses, illustrates that by the time these patients—mostly elderly males—reached the tertiary care center, the disease was often already characterized by extensive spread. For example, 49-year-old Md Aslam already presented with adrenal and lymph node metastasis at the time of his scan.

In summary, the demographic data from this 23-patient series confirms that carcinoma lung in this tertiary care center predominantly affects males in their 60s, though it maintains a presence across a vast age range from late adolescence to late senescence.

CT Diagnostic Findings and Morphological Spectrum

Computed Tomography (CT) serves as the definitive imaging modality for characterizing the primary

pulmonary lesion and identifying the extent of disease in suspected bronchogenic carcinoma. In this case series of 23 patients, CT imaging provided a comprehensive spectrum of the primary tumor's morphology and its impact on surrounding thoracic structures.

Primary Tumor Characteristics

The majority of cases in this series were radiologically diagnosed as bronchogenic carcinoma or carcinoma lung. CT imaging typically demonstrates a primary lung mass, often characterized by irregular or spiculated margins, which are hallmarks of malignancy. The detailed cross-sectional visualization provided by CT allowed for the precise assessment of:

- **Tumor Size and Location:** CT accurately mapped the primary site, such as the left bronchogenic carcinoma identified in Ashok Masram.
- **Invasion of Adjacent Structures:** Imaging highlighted the relationship between the tumor and the mediastinum, as seen in cases where the malignancy was noted to be abutting the mediastinal structures.

Vascular Involvement and Complications

One of the most critical diagnostic contributions of CT in this study was the identification of vascular invasion and secondary complications. Advanced bronchogenic carcinoma frequently involves the great vessels of the mediastinum:

- **SVC Abutment:** Atmaram Nandanwar (67/M) exhibited a bronchogenic carcinoma directly abutting the Superior Vena Cava (SVC).
- **Venous Thrombosis**: In more severe cases, CT identified secondary vascular events. Ghasita Yadav (55/M) presented with a primary lung carcinoma that had caused total thrombosis of the SVC and the right brachiocephalic vein. Another case (Case 3) similarly demonstrated SVC and right brachiocephalic vein thrombosis.

Representative Morphological Findings

The "CT spectrum" described in this series often included a combination of the primary mass and its secondary effects on the lung and airways. Findings included:

- **Mass with Nodal Association:** Most cases, such as those of Rashid Abdul and Chotelal Patel, showed a primary mass inextricably linked with significant mediastinal and hilar lymphadenopathy.
- **Neoplastic Etiology:** Some scans, such as that of Shaheda Begum, were reported broadly as "neoplastic etiology of the lung," indicating a high radiological suspicion of malignancy based on the mass's appearance.

Diagnostic Indispensability

The study concludes that CT is indispensable for the evaluation of lung carcinoma because it provides a "spectrum" of findings—from the primary parenchymal mass to complex vascular involvement. The recognition of these characteristic imaging patterns, such as mass morphology and vascular abutment, is essential for clinical staging and the formulation of a management plan. Without the detailed anatomical mapping provided by CT, determining the feasibility of surgical resection or radiation therapy would be impossible.

4.3 Metastatic Patterns

Metastatic Patterns and Systemic Spread

In the clinical evaluation of lung cancer, identifying the pattern of spread is as critical as characterizing the primary tumor itself. This case series of 23 patients demonstrates that bronchogenic carcinoma is a highly aggressive malignancy that utilizes multiple anatomical pathways—lymphatic, hematogenous, and local-regional—to disseminate throughout the body. By the time patients presented to the tertiary care center, a significant number already exhibited multi-organ involvement, which fundamentally alters the TNM staging and the subsequent therapeutic approach.

Lymphatic Dissemination

The most frequent pathway of spread identified in this study was via the lymphatic system. This typically manifests as enlargement of the hilar and mediastinal lymph nodes.

- **Mediastinal Lymphadenopathy:** This was a hallmark finding in several cases, including Rashid Abdul (62/M) and Chotelal Patel (75/M).
- **Hilar Involvement:** Ipsilateral hilar node enlargement often represents the first "station" of spread before reaching the central mediastinum.

Local-Regional Spread: Pleural and Pulmonary

Local invasion occurs when the tumor breaches the visceral pleura or seeds the pleural cavity.

- **Pleural Metastasis:** This was documented in patients such as Ashok Masram (72/M), often appearing as nodular pleural thickening or associated malignant effusions.
- **Satellite Nodules: P**ulmonary parenchyma metastasis was observed in the form of satellite nodules, which are separate tumor foci within the lung tissue. Chotelal Patel and Md Aslam both exhibited these secondary intrapulmonary deposits.

Hematogenous and Distant Metastasis

Hematogenous spread occurs when cancer cells enter the bloodstream, allowing them to deposit in distant, highly vascular organs.

- **Adrenal Gland Metastasis:** The adrenal glands are a classic site for lung cancer seeding. In this series, Md Aslam (49/M) presented with documented adrenal metastasis.
- **Systemic Involvement:** Other patients, such as Tahera Bee (71/F) and Sinddhutai Bonkar (55/F), were noted to have "distant metastasis" or "metastasis" generally, reflecting a systemic disease state.

Vascular Invasion and Great Vessel Involvement

A unique and clinically grave metastatic pattern observed in this cohort involves the direct invasion or compression of the great vessels within the mediastinum.

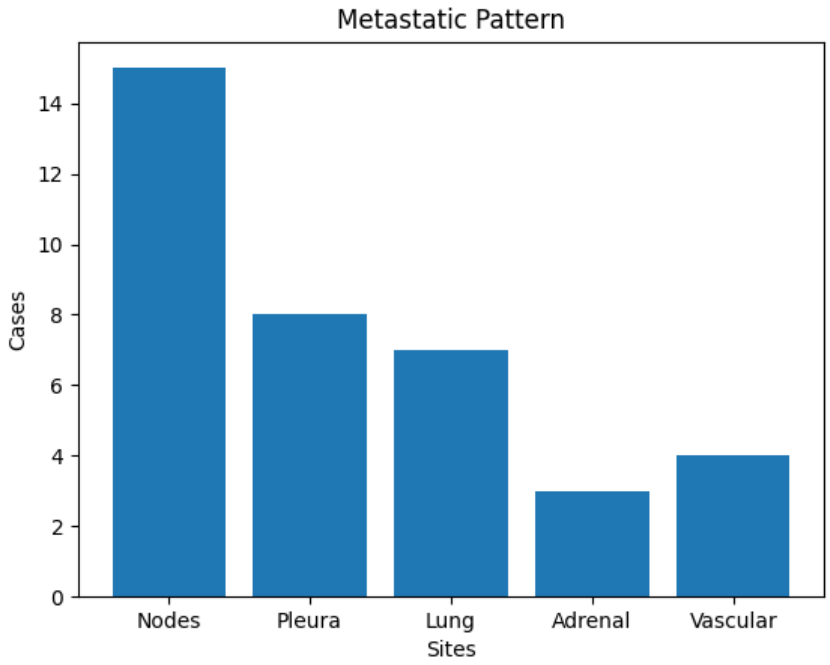
- **SVC Abutment:** Atmaram Nandanwar (67/M) demonstrated a mass directly abutting the superior vena cava (SVC).
- **Thrombosis:** The most advanced vascular complication noted was the complete thrombosis of the SVC and right brachiocephalic vein, as seen in Ghasita Yadav (55/M). This often leads to Superior Vena Cava Syndrome, a clinical emergency.

Clinical Significance

The recognition of these patterns on CT is essential because the presence of distant metastasis (M1) or extensive nodal involvement (N2/N3) typically precludes curative surgical resection. In this series, the high frequency of advanced findings—ranging from adrenal deposits to venous thrombosis—highlights the necessity of comprehensive CT staging to avoid unnecessary surgeries and to transition patients toward appropriate systemic therapies or palliative care.

Metastatic disease was identified in a high percentage of patients, illustrating the aggressive nature of the disease at the time of imaging:

Metastatic Site	**Specific CT Findings**
Lymph Nodes	Mediastinal and hilar lymphadenopathy
Pleura	Pleural metastasis and nodular deposits
Pulmonary	Satellite pulmonary nodules in different lobes
Adrenal Glands	Systemic spread identified in specific cases
Vascular	SVC abutment and thrombosis of the SVC/brachiocephalic vein



Discussion

The analysis of this case series, encompassing 23 patients treated between 2019 and 2025, underscores the critical role that Computed Tomography (CT) plays in the modern oncological workflow for lung cancer. Lung carcinoma remains the leading cause of cancer-related mortality globally, often due to its silent progression and late-stage presentation. In this study, the clinical and radiological profiles of the patients align with established global epidemiological trends, particularly regarding age and gender distribution.

Demographic and Clinical Correlations

The study observed a marked male predominance, with approximately 74% of the cohort being male. This skew is traditionally attributed to higher historical rates of smoking and occupational exposure among men, though the gap is narrowing in many regions. The mean age of 63 years and the peak incidence in the 6th and 7th decades of life highlight lung cancer as a disease primarily affecting the elderly population. However, the inclusion of a 17-year-old patient (Aniket Unate) and a 33-year-old patient (Anusuya Bandewar) serves as a poignant reminder that while rare, primary lung malignancy can occur in younger demographics, often presenting unique diagnostic challenges.

The Role of CT and CECT in Diagnosis

Computed Tomography is the primary imaging modality for evaluating lung malignancies because it allows for a non-invasive, highly detailed assessment of the thoracic cavity. While standard CT provides excellent detail of the lung parenchyma, Contrast-Enhanced Computed Tomography (CECT) is essential for distinguishing between vascular structures, collapsed lung tissue, and the tumor mass itself.

In our series, CT was instrumental in identifying:

- **Primary Tumor Characteristics:** Assessment of size, spiculated margins, and density.
- **Nodal Involvement:** Detection of mediastinal and hilar lymphadenopathy, which was the most frequent metastatic finding in this study.
- **Vascular Complications:** Identification of superior vena cava (SVC) abutment (Atmaram Nandanwar) and thrombosis (Ghasita Yadav), which significantly impacts the patient's performance status and treatment options.

Metastatic Pathways and Patterns

The study highlighted the three primary pathways through which lung cancer disseminates:

1. **Lymphatic Spread:** This is the most common route, leading to the involvement of hilar and mediastinal lymph nodes. In cases like Rashid Abdul and Chotelal Patel, CT clearly demonstrated extensive nodal metastasis, which is a key factor in upstaging the disease.
2. **Hematogenous Spread:** This pathway accounts for distant metastases to highly vascular organs. The case of Md Aslam (49/M) is a classic example, showing spread to the adrenal glands, a common site for hematogenous seeding in lung cancer.
3. **Local Invasion and Seeding:** Direct extension into the pleura can result in pleural effusions or nodular deposits, as seen in the case of Ashok Masram. Pulmonary satellite nodules represent another form of local-regional spread within the lungs.

TNM Staging of Lung Cancer

Accurate staging is the foundation of lung cancer management, as it determines whether a patient is a candidate for surgical resection, chemotherapy, radiation, or palliative care. The internationally recognized standard is the TNM system:

T (Tumor)

Describes the size and location of the primary tumor and whether it has grown into nearby structures.

- T1: Tumor ≤ 3 cm.
- T2: Tumor > 3 cm but ≤ 5 cm, or involvement of the main bronchus.
- T3: Tumor > 5 cm but ≤ 7 cm, or invasion of the chest wall, phrenic nerve, or parietal pericardium.
- T4: Tumor > 7 cm or invasion of vital structures like the heart, great vessels (e.g., SVC), trachea, or esophagus. In this study, cases showing SVC abutment or thrombosis fall into this advanced category.

N (Nodes)

Describes whether the cancer has spread to regional lymph nodes.

- N0: No regional lymph node metastasis.
- N1: Metastasis in ipsilateral peribronchial and/or ipsilateral hilar lymph nodes.
- N2: Metastasis in ipsilateral mediastinal and/or subcarinal lymph nodes.
- N3: Metastasis in contralateral mediastinal, contralateral hilar, or supraclavicular lymph nodes.

M (Metastasis)

Describes whether the cancer has spread to distant parts of the body.

- M0: No distant metastasis.
- M1a: Separate tumor nodules in a contralateral lobe; tumor with pleural or pericardial nodules or malignant effusion.
- M1b: Single extrathoracic metastasis in a single organ.
- M1c: Multiple extrathoracic metastases in one or several organs. The case of Md Aslam, with adrenal and pulmonary metastasis, represents this advanced stage.

Prognostic Implications

The imaging findings in this series generally point toward advanced-stage disease at the time of presentation. Vascular invasion, such as SVC thrombosis, and distant metastases to the adrenal glands or pleura are indicators of a poorer prognosis. In developing regions, the lack of widespread screening programs often results in patients seeking medical attention only after symptomatic progression, by which time the cancer has frequently reached stage III or IV.

6. Limitations and Conclusion

6.1 Limitations

The study acknowledges several constraints:

- **Sample Size:** The cohort consisted of 23 patients.
- **Methodology:** It was a retrospective study.
- **Correlation:** There was a lack of histopathological correlation for every single case.
- **Follow-up:** Long-term survival and follow-up data were limited.

6.2 Final Conclusion

Conclusion

The findings of this retrospective case series underscore the indispensable role of Computed Tomography (CT), particularly Contrast-Enhanced Computed Tomography (CECT), in the comprehensive management of lung carcinoma within a tertiary care setting. By analyzing 23 patients over a six-year period, the study demonstrated that CT is not merely a tool for initial detection but a critical map for anatomical staging and treatment planning.

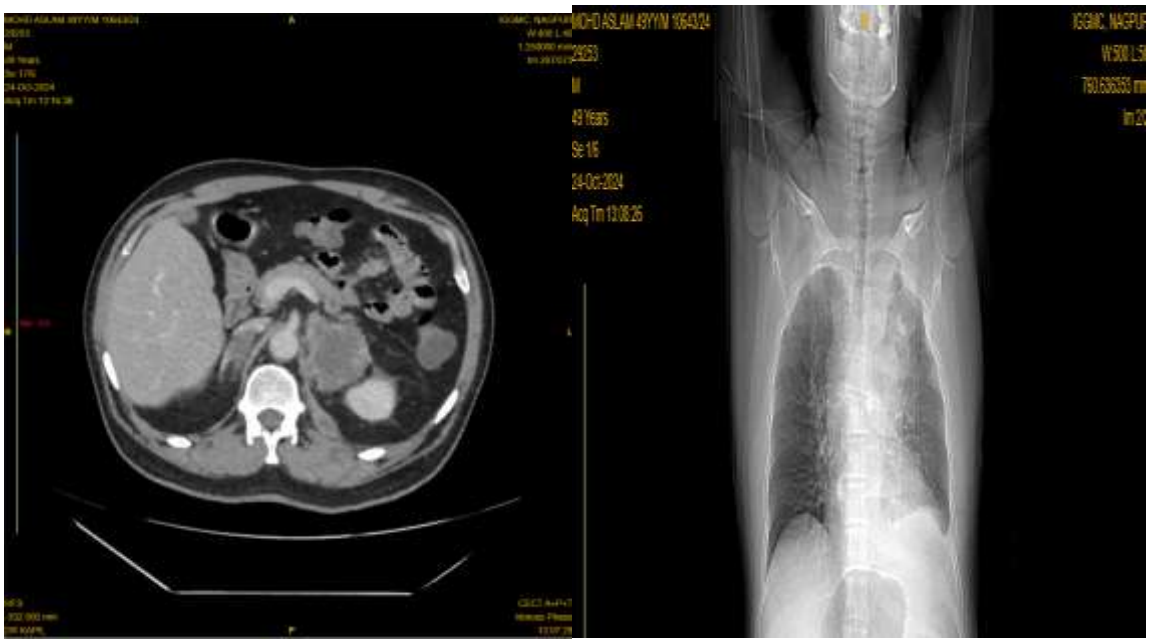
The imaging spectrum observed in this cohort confirms that bronchogenic carcinoma often presents at an advanced stage, characterized by complex metastatic patterns. The most frequent radiological findings included primary parenchymal masses associated with extensive mediastinal and hilar lymphadenopathy. Furthermore, the ability of CT to detect systemic spread—such as the adrenal metastasis seen in one patient—and critical vascular complications, such as superior vena cava (SVC) abutment and thrombosis, highlights its diagnostic depth.

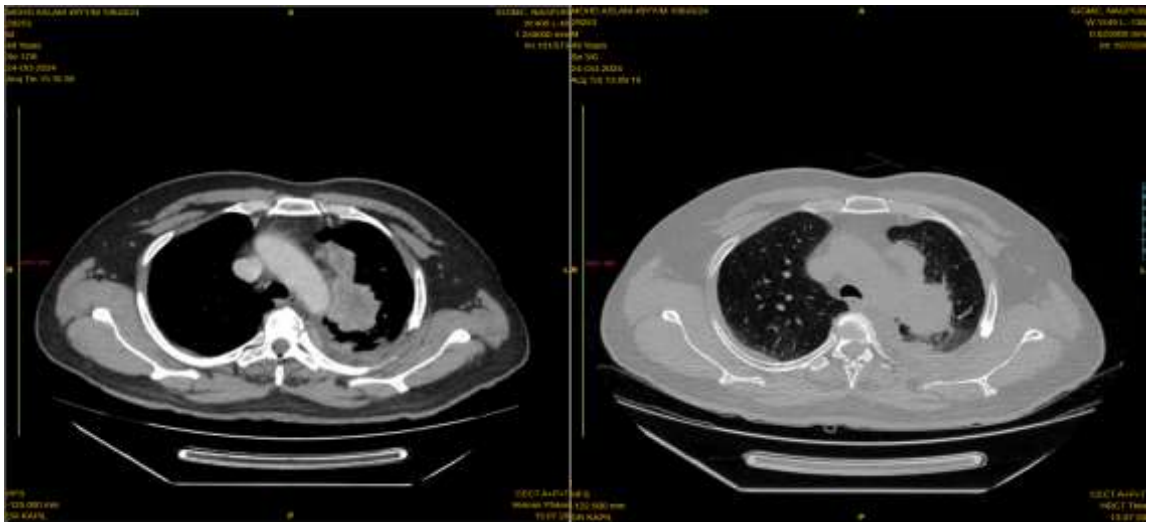
Demographically, the study aligns with global trends, showing a peak incidence in the 6th and 7th decades of life and a significant male predominance (~74%). However, the inclusion of younger patients in the series emphasizes that clinical vigilance must extend across all adult age groups.

In summary, the recognition of characteristic CT imaging patterns is essential for accurate TNM staging, which directly informs the transition between curative intent and palliative care. While the study is limited by its retrospective nature and sample size, it reinforces that early and detailed CT evaluation is a vital factor in influencing treatment trajectories and improving the overall prognostic outlook for patients facing a diagnosis of lung carcinoma. The integration of these radiological insights ensures that clinicians can navigate the complexities of this aggressive malignancy with greater precision and therapeutic efficacy

Representative Cases

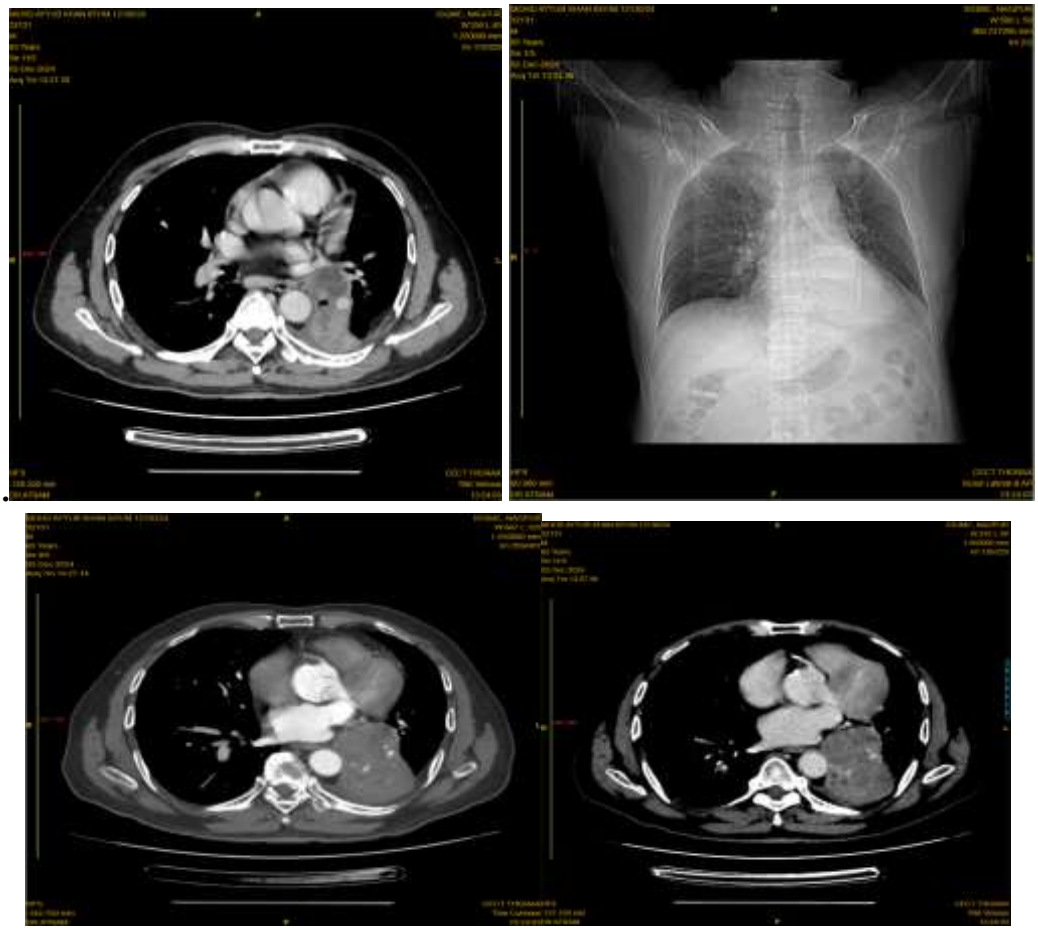
1. **Case 1:** A 49-year-old male presenting with a primary lung mass accompanied by extensive pleural, pulmonary, adrenal, and lymph node metastases.



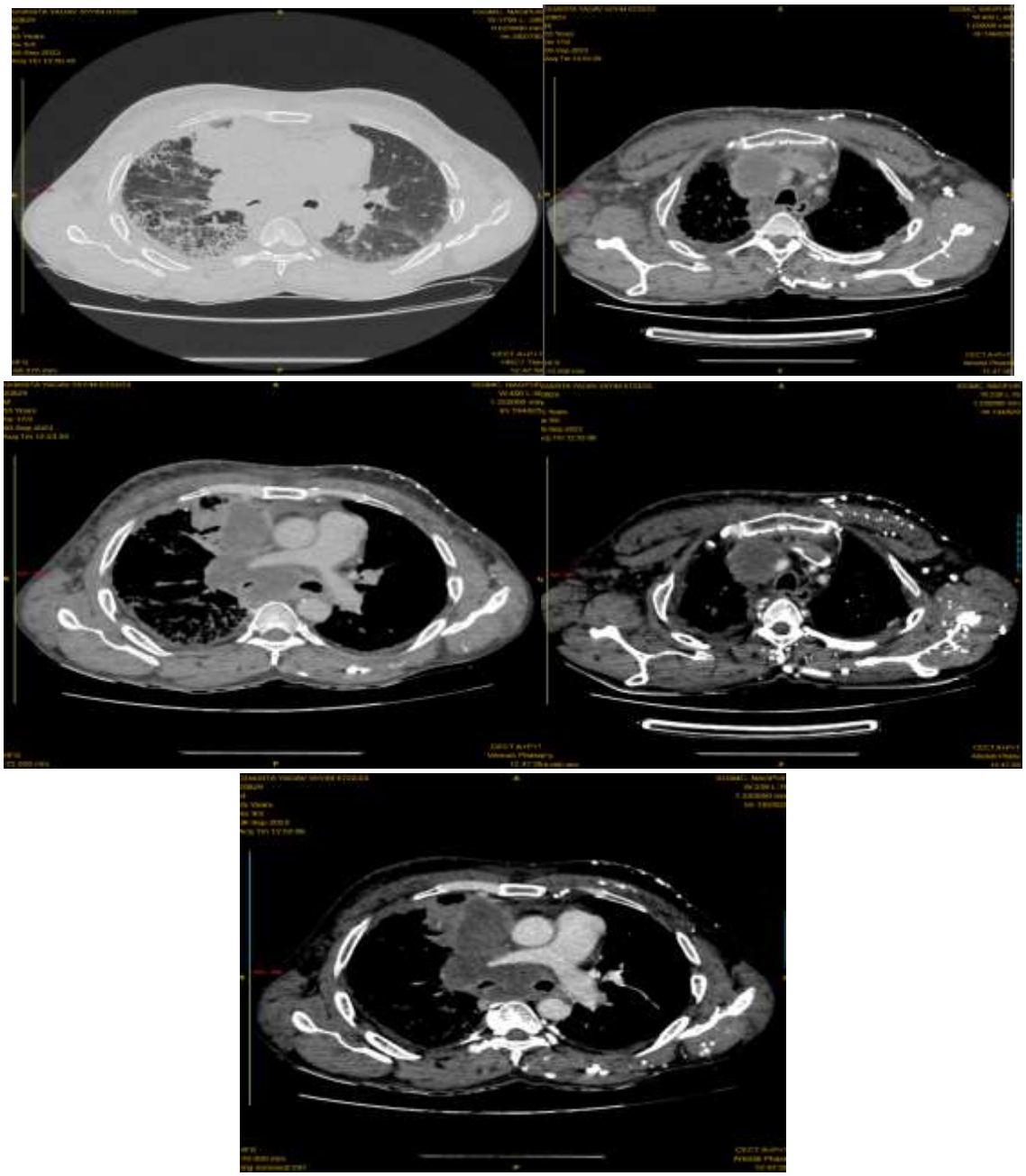


There is an ill-defined heterogeneously enhancing soft tissue density mass with spiculated margins and central non enhancing necrotic area, noted epicentered over left hilum in apico-posterior segment of left upper lobe showing bronchus cut off sign with adrenal metastasis

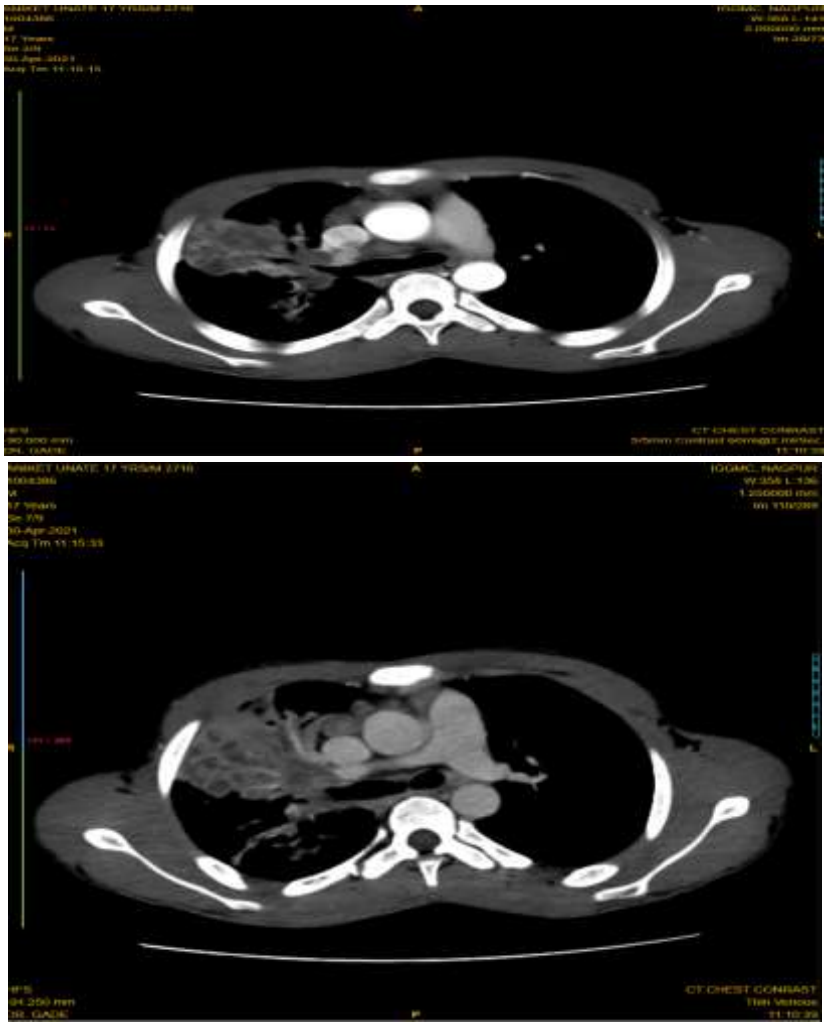
Case) BRONCHOGENIC CARCINOMA



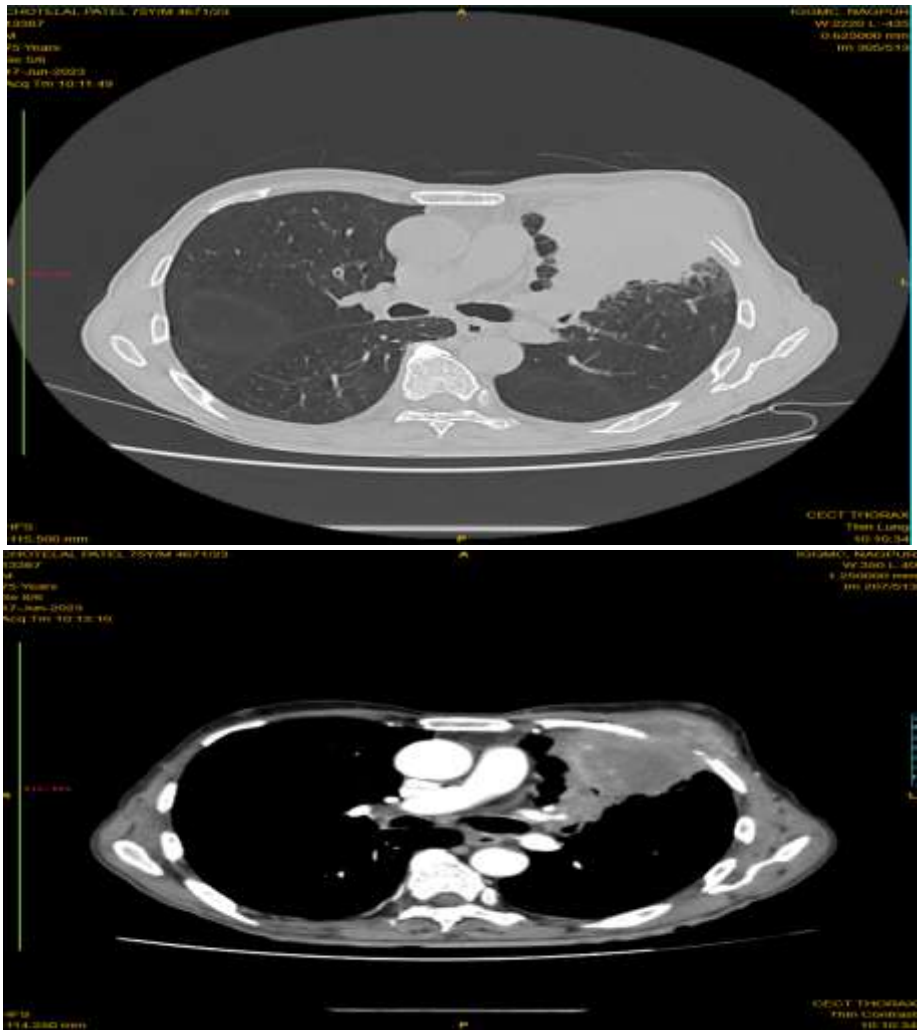
Case) Carcinoma Lung with Thrombosed Svc and Right Brachiocephalic Vein



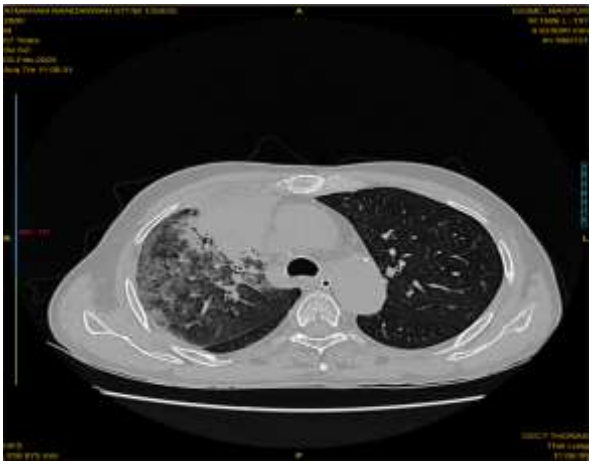
Case) CA lung in a 17 year old.

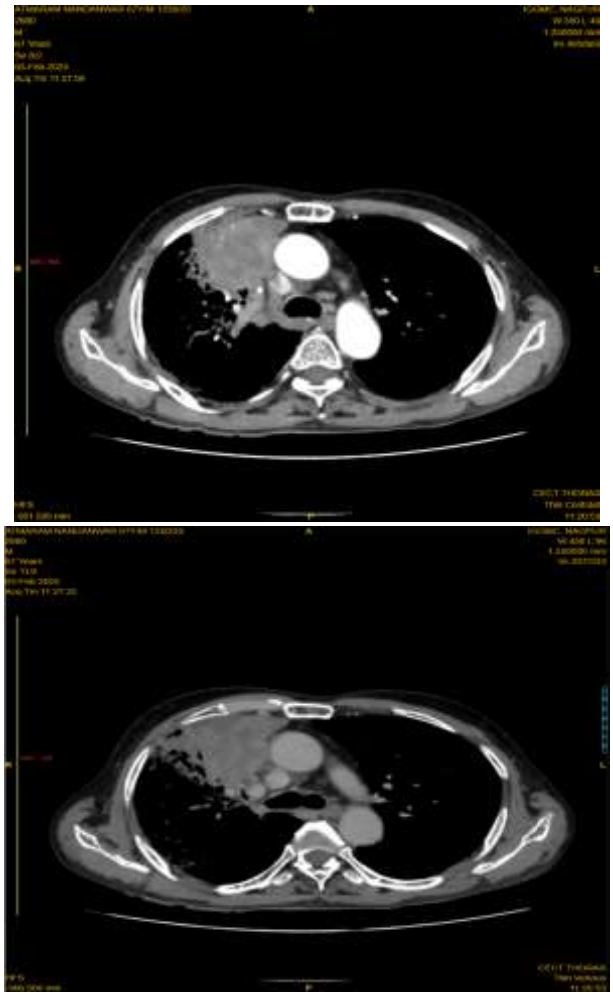


Case) CA lung with chest invasion

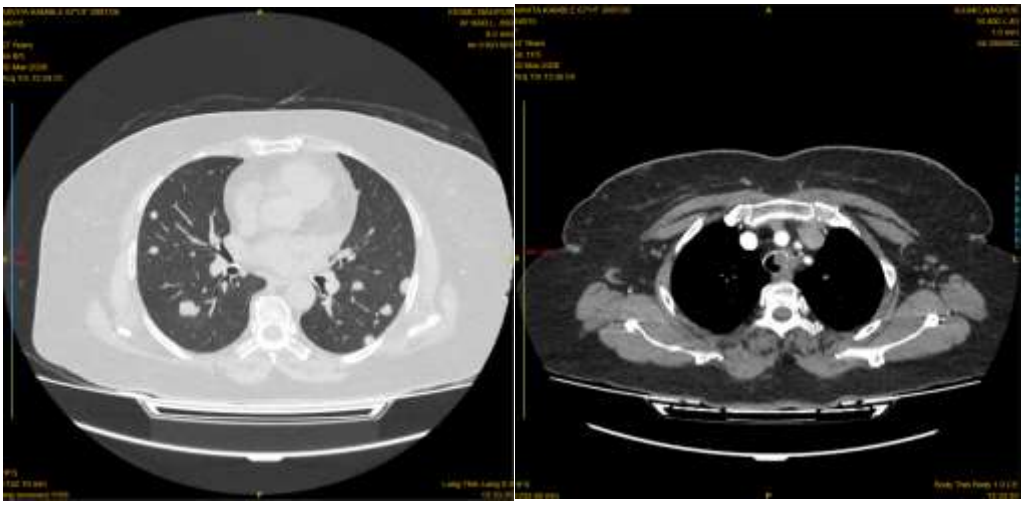


Case) bronchogenic carcinoma with abutting svc





Case) Tracheal CA



- A relatively well-defined heterogeneously enhancing soft tissue density mass lesion is noted arising from the left lateral wall of the trachea at the level of T2 vertebra,
  - The lesion is seen projecting into the tracheal lumen, causing partial luminal narrowing with an approximate reduction of the airway caliber by 50%.
  - The proximal and distal tracheal segments appear patent.
  - No definite evidence of extratracheal extension into the adjacent mediastinal fat planes is noted.
  - No obvious cartilage destruction is identified.

Above imaging features are likely suggestive of malignant neoplastic etiology of trachea. Suggested endotracheal biopsy and HPE correlation.

- Multiple, variable-sized, well-defined round to oval heterogenously enhanching soft tissue density nodules are noted involving the bilateral lung parenchyma, , suggestive of pulmonary metastatis.SSS