SPECTRUM OF FINDINGS IN PULMONARY INFECTIONS ON CT / HRCT SCAN OF THE CHEST
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ABSTRACT: For most clinicians, the definition of pneumonia is the presence of an abnormal opacity on chest radiograph and symptoms of respiratory infection such as cough, mucus production, fever etc. The radiological signs of infection of the lower bronchial tree can be caused by other lung diseases also. The role of imaging in pulmonary infection is to determine the presence of, localization of, and extent of infection, to detect predisposing factors, to detect complications and in follow up of the infection. Radiological signs are often not very typical and have a limited role in predicting the cause and infecting organisms. The computed tomography (CT) scan with post contrast study whenever required and high resolution computed tomography(HRCT) are the best available modalities to assess the lung parenchyma, interstitium, mediastinum and pleura. A retrospective analysis of 100 cases of respiratory diseases who had undergone CT/HRCT scan in department of radiology at Terna Sahyadri Specialty Hospital and Research Centre, Navi Mumbai was done to know the predominant findings, variety of lesions and appearances in this pictorial assay.

KEYWORDS: Computed tomography (CT), high resolution computed tomography (HRCT), pulmonary infection, pneumonia.

ABBREVIATIONS: ABPA – Allergic broncho pulmonary aspergillosis.

INTRODUCTION: Despite advances in diagnosis and treatment, pulmonary infections are a major cause of mortality and morbidity in adult patients. The spectrum of organism known to cause respiratory infections is broad and is constantly increasing as new pathogens are identified and host immune response is altered by medications or other diseases or responses.

The clinician evaluating the patient with a known or suspected pulmonary infection faces the diagnostic challenge because of clinical overlap of signs and symptoms and variable radiological manifestations. The number of immunocompromised patients has dramatically increased because of AIDS epidemic, advances in cancer chemotherapy and expanding organ transplantation.(1)

CT, more so HRCT study of the chest, has become a frontline investigation for evaluation of such patients. In essence HRCT seeks to maximize spatial resolution and thereby approach a morphological/pathological representation of the disease process.(2)

MATERIALS AND METHODS: A retrospective study of 100 patients with chest infections was done to analyze the spectrum of findings of pulmonary infections on CT / HRCT scans of the chest. Majority of the cases underwent plain / HRCT study of the chest with intravenous contrast enhanced studies performed in a few of the patients.
The study included patients of all age groups and included both male and female patients. The scans were performed on a Siemens Somatom Sensation 64 multi detector CT scan machine. Nonionic intravenous contrast was used for the contrast enhanced studies. Images were mainly documented using lung and mediastinal windows. HRCT sections were displayed using 1 mm slice thickness at periodic intervals and the HRCT sections were obtained in deep inspiration as far as possible.

DISCUSSION AND CASE REPORT: Retrograde analysis of 100 patients was considered as collected data and grouped as per their CT findings in a variety of subgroups as consolidation, ground glassing, nodules, bronchiectasis, cavities, pleural fluid / effusion / collection, lymph nodes and post infective sequelae. Data obtained is given in a master table below.

| Sex | Age groups in years | Consolidation | Ground glassing | Nodules | Bronchiectasis | Pleural fluid | Cavities | Post infective sequelae | Lymph nodes |
|-----|---------------------|---------------|-----------------|---------|----------------|--------------|----------|------------------------|-------------|
| M   | 1-10=0              | 88 (88%)      | 24 (24%)        | 48 (48%)| 24 (24%)       | 34 (34%)     | 16 (16%) | 28 (28%)               | 100 (100%) |
|     | 58                  |               |                 |         |                |              |          |                        |             |
|     | 42                  |               |                 |         |                |              |          |                        |             |
|     | 11-20=6             |               |                 |         |                |              |          |                        |             |
|     | 21-30=10            | Lobar=22 (25%)|                 |         |                |              |          |                        |             |
|     | Segmental=8 (9%)    | Airspace-10 (20.8%) | Traction-12 (50%) | Right-16 (47%) | Multiple-8 (50%) | Scarring-22 (78.5%) | Mediastinal-80 (80%) | Hilar-20 of 100 (20%) - right 14, left 6 |
|     | 31-42=22            | Patchy-12 (13.6%) | Calcified-6 (8%) |          |                |              |          |                        |             |
|     | 41-50=18            | Multifocal-24 (27.2%) | Miliary-4 (8.3%) | Simple effusion-30 (88.2%) | Crescent sign-2 (12.5%) |          |                        |             |
|     | 51-60=10            | Air bronchograms-12 (13.6%) | Centrilobula r-2 (4.1%) |                   |                   |          |                        |             |
|     | 61-70=16            | Cavitation or breakdown-10 (11.4%) |                   |                   |                   |          |                        |             |
|     | 71-80=16            |                   |                   |                   |                   |          |                        |             |
|     | 81-90=2             |                   |                   |                   |                   |          |                        |             |
|     | 91-100=0            |                   |                   |                   |                   |          |                        |             |

There was more than one or a spectrum of findings in most patients. The objective analysis of the data revealed consolidation to be the dominant form of presentation in chest infections, 88 out of 100 patients (88%).

CONSOLIDATION (Figures 1to 4): The term consolidation means increased lung attenuation with obscuration of pulmonary vessels. By definition diseases that produce consolidation are characterized by replacement of alveolar air by another substance such as blood, pus, edema or cells. Consolidation may be lobar as in klebsiella, pneumonia, segmental, patchy/ sub segmental or multifocal.

Bronchopneumonia typically shows patchy pattern or a homogenous segmental consolidation. Gram negative, anaerobic bacteria and occasionally streptococcus pneumonia are responsible for breakdown and abscess formation with subsequent cavitation. An air bronchogram is usually associated with lobar pneumonia and suggests air in bronchi against a background of consolidation.
An air bronchogram is usually reassuring of a non-obstructive etiology, but can be seen also in cases of bronchoalveolar carcinoma and lymphoma.

In our 88 cases of pneumonias 22 (25%) had lobar pneumonia, 27.2% had multifocal pneumonias, 13.6% had patchy pneumonias, 12 patients (13.6%) had air bronchogram and 10 had cavitation or breakdown (11.4%). Out of 88 patients, 9 % had segmental pneumonia.

GROUND GLASS OPACITY: Ground glass opacity is defined as hazy increase in lung attenuation that is not obscuring the underlying vessels.\(^{(2)}\) It could be alveolar, interstitial or alveolo-interstitial in location. Ground glass opacity is a highly significant finding as it often indicates the presence of an ongoing active and potentially treatable process.

It is commonly seen in immunocompromised patients with pneumocystis pneumonia.\(^{(2)}\)\(^{(5)}\)

When associated with thickening of the interlobular septa it is called crazy paving and can be seen in pneumocystic jiroveci pneumonia.\(^{(5)}\) In patients with acute symptoms as in infections, association of ground glassing with active disease is very high. In our study, ground glass opacity was present in 24 out of 100 patients (24%).
NODULES: A pulmonary nodule may be broadly defined as any relatively sharply defined, discrete, nearly circular opacity within the lung ranging in size from 2-30mm. Micro nodules are referred to nodules less than 3-7 mm. Miliary nodules are usually innumerable, measuring 1-3 mms in sizes scattered throughout the lungs. They can be seen in pulmonary tuberculosis. Nodules may be centrilobular, perilymphatic or random in location and can be of ground glass or soft tissue attenuation. A tree in bud appearance consists of linear branching opacities connected to centrilobular nodules of soft tissue attenuation that has more than one branching site. This sign corresponds with bronchial dilatation filled with mucus, pus or fluid. These can be seen in tuberculosis, bacterial infections and ABPA.

In our study, 48 out of 100 patients (48%) had nodules out of which 10 patients (20.8%) had airspace nodules and nodular consolidation was seen in 8 out 48 (16.6%) patients. Six patients out of 48 (8%) had calcified nodules. Only 4 out of 48 (8.3%) had miliary nodules and 2 out of 48 (4.1%) had centrilobular nodules.
BRONCHIECTASIS: Bronchiectasis is generally defined as localized irreversible bronchial dilatation\(^2\) often with thickening of the bronchial wall. Bronchial dilatation is the most specific sign and is present when the broncho-arterial ratio exceeds one.\(^2\)

The dilatation is seen as signet ring sign on cross section.\(^2\)(5) In order of increasing severity, bronchiectasis has been classified into cylindrical, varicose and cystic varieties. Other signs of bronchiectasis include lack of bronchial tapering, visualization of peripheral airways, mucoid impaction.\(^4\)

A finger in glove sign also called as inverted V or Y, cluster of grapes sign is formed by mucoid impaction within the dilated bronchial tree. Mucoid impacted dilated bronchial tree is commonly seen in allergic bronchopulmonary aspergillosis with central bronchiectasis also noted in this condition.\(^3\)(6)

Bronchiectasis with or without mucoid impaction can also be seen in tuberculosis and other bacterial infections.\(^5\) Traction bronchiectasis is seen in areas of scarring or fibrosis where there is traction on the walls of the bronchi by fibrous tissue. In our study 24 out of 100 (24%) had bronchiectasis out of which 12 patients (50%) had traction bronchiectasis?

CAVITY: A cavity is a lucency exceeding one cm in diameter and surrounded by a complete wall which is a 3 mm or more in thickness.\(^2\) Bacterial infections like staphylococcus aureus, klebsiella and anaerobic bacteria commonly result in development of thick or thin walled cavitation’s.\(^3\) Pneumatoceles are thin walled cavitatory lesions commonly seen in children.\(^3\)

Gram negative, anaerobic and occasionally streptococcus pneumonia are responsible for lung abscesses which are seen characteristically as a thick walled cavity with or without fluid levels \(^3\). A crescent sign suggests intra cavitatory contents with a thin crescent of residual air.\(^3\)(4) Crescent sign is commonly seen in fungal infections as in an aspergilloma.\(^3\) Areas of cavitation can also be commonly found in tuberculosis.

In our study of 100 patients, we found cavities in 16 of those patients (16%). Out of these 16 cases of cavities, 8 had multiple cavities (50%) and 4 had single cavities (25%). Heterogenous densities were seen in 2 out of 16 cavities (12.5%) and crescent sign was seen in 2 out of the 16 cases (12.5%).
LYMPH NODES: Hilar and mediastinal lymph nodes are commonly seen in all most all patients with active tuberculosis and in HIV positive patients.\(^5\) Mediastinal lymphadenopathy is more commonly seen in HIV positive patients as compared to sero negative patients. Hilar lymphadenopathy in ABPA is probably due to reactive hyperplasia of lymphoid tissue.\(^6\)

Involved lymph nodes may show a typical rim enhancing pattern suggestive of central necrosis in tuberculosis.\(^4\) Lymph nodal calcification could be seen as a natural course of the disease or secondary to treatment. Lymph nodal enlargement / involvement secondary to infection normally do not encase vessels. They may however cause airway compression with post obstructive changes distally.

In our study, lymph node enlargement was seen in all the patients (100%). Out of these 80 had predominantly mediastinal lymph node enlargement (80%) and 20 had predominantly hilar enlargement (20%). There was considerable overlap in both groups; subcarinal and precarinal group was involved in almost 50 cases of all. Calcification was seen in 20 of 100 lymph nodes (20%) and necrosis within lymph nodes was seen in 8 of 100 cases (8%).
Fig. 14: Non calcific pretracheal, right paratracheal and perivascular lymphadenopathy

Fig. 15: Azygoesophageal lymphadenopathy causing esophageal compression

Fig. 16: Discrete enhancing pretracheal and aortopulmonic lymph nodes

Fig. 17: Enhancing right Hilar & subcarinal lymph nodes

Fig. 18: Calcified pretracheal lymph nodes
PLEURAL EFFUSION / FLUID / COLLECTION: Generally, collections of pleural fluid are recognized on CT scan of thorax as arcuate areas of homogenous density paralleling the chest wall. It is a common complication in tuberculosis where it is mostly exudative and commonly unilateral.(5)

Pleural fluid can accumulate in patients with pneumonia even when the pleural space is uninfected. This syn / para pneumonic effusion occurs due to increase in the visceral pleura permeability. Empyema describes a purulent pleural effusion resulting from infection of the pleural space. Contrast enhanced sections reveal the split pleura sign in such cases.

In our study we found pleural fluid in 34 out of 100 cases (34%). Out of these 34 cases of pleural effusion, 16 had right sided involvement (47%), 14 had left sided collection (41.1%), and 4 of 34 (11.7%) had both sided collections. Out of total 34 cases, 30 cases had simple pleural effusion (88.2%), 2 had loculated collection and 2 had empyema, i.e., 5.9% each.

Fig. 19: Right pleural fluid with thickened layer

POST INFECTIVE SEQUALAE: These represent telltale evidence of any previous infection and usually represent an inactive stage. These could be in the form of volume loss, parenchymal scarring, fibronodular or fibrocalcific densities and compensatory hyperinflation. Fibrocavitatory lesions on the other side merit clinic pathological correlation to exclude activity. In our study we found 28% cases with post infective sequelae. Scarring was seen in 22 out of 28 cases (78.5) and 6 had fibrocalcific lesions. (21.5%)

Fig. 20: Bilateral Fibronodular scarring in upper lobes
CONCLUSIONS: It can thus be concluded that there could be a spectrum of findings with overlap on CT scan in pulmonary infections. Lymph node enlargement is found in all cases 100% in our study of positive cases of pulmonary infections. Pneumonia consolidation was present in 88 % of cases followed by nodules in 48%, pleural effusion in 34 % and post infective sequelae in 28 % of patients.

The ground glass opacities and bronchiectasis were present in 24 % of patients each. Cavities were present in 16% of patients and were predominantly tuberculous in origin. The multifocal consolidation was the most common of all pneumonias. (27.2%) These usually favor an infective etiology.

Areas of ground glassing suggest a potentially treatable active ongoing process in acute symptomatology. Calcifications in lymph nodes s/o chronicity was more predominant (20%) than the central necrosis (8 %). Areas of necrosis in enlarged lymph nodes in an appropriate clinical setting favors tuberculous etiology. Tree in bud appearance suggest end bronchial spread of infection. Split pleura sign with enhancing pleural layers suggest empyema formation.

Thus CT/HRCT findings gave us an overlap of findings which gives us more insight in to the disease process and when correlated with the clinical, pathological / hematological reports, it helps us to narrow the differential diagnosis. These findings are useful in diagnosing the variety and severity of pulmonary infections and thus help in further management and treatment of potentially curable chest diseases like infections and help in preventing further complications.

**MASTER TABLE** depicting the spectrum of chest lesion and their overlapping percentage wise occurrences in 100 patients.

| Set | Age groups in years | Consolidation | Ground glassing | Nodules | Bronchiectasis | Pleural fluid | Cavities | Post infective sequelae | Lymph node |
|-----|---------------------|---------------|----------------|---------|----------------|---------------|---------|------------------------|------------|
| F   | 1-10<6              | 66            | 34             | 34      | 34             | 16            | 20      | 100                    | 38         |
|     | 11-20<6             |               | (24%)          | (48%)   | (24%)          | (24%)         | (8%)    |                        |            |
|     | Lobar-22 (15%)     | Lobar-10 (23%)|                |         |                |               |         |                        |            |
|     | 21-30<10            | Segemental-8  (9%) | Nodular consoliaton-8 (164%) |       |               |               |         |                        |            |
|     |                     |               |                |         |                |               |         |                        |            |
|     | 31-40<22            | Fissity-12 (126%) | Ground glassing-6 (8%) | Both sided-4 (11%) | Heterogeneous densities with-2 (126%) | Necrotic - 8 of 100% |        |                        |            |
|     |                     |               |                |         |                |               |         |                        |            |
|     | 41-50<18            | Multifocal-24 (272%) | Nodular-4 (8.3%) | Simple effusion-30 (88.3%) | Crescent sign-2 (126%) | Calcié - 8 of 100% |        |                        |            |
|     |                     |               |                |         |                |               |         |                        |            |
|     | 51-60<10            | Air bronchograms-12 (126%) | Centrilobular-2 (10%) | Empyema-2 (8.3%) |                        |                |         |                        |            |
|     |                     |               |                |         |                |               |         |                        |            |
|     | 61-70<16            | Cavitation or breakdown-10 (114%) |                        | Louflated-2 (5.9%) |                        |                |         |                        |            |
|     |                     |               |                |         |                |               |         |                        |            |
|     | 71-80<16            |                 |                |         |                |               |         |                        |            |
|     | 81-90<2              |                 |                |         |                |               |         |                        |            |
|     | 91-100<0             |                 |                |         |                |               |         |                        |            |
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