Clinical and radiological features of chest calcifications: distribution, appearance and underlying causes.

Poster No.: P-0108
Congress: ESTI 2019
Type: Educational Poster
Authors: F. Libra¹, M. Palermo², G. Distefano³, F. Tiralongo¹, S. Torrisi¹, A. Libra¹, A. Vancheri¹, A. Basile¹, C. Vancheri¹, S. Palmucci¹; ¹Catania/IT, ²Catania/IT, ³Ragusa/IT
Keywords: Thorax, Mediastinum, Lung, CT-High Resolution, Conventional radiography, CT, Education, Calcifications / Calculi, Education and training

Any information contained in this pdf file is automatically generated from digital material submitted to EPOS by third parties in the form of scientific presentations. References to any names, marks, products, or services of third parties or hypertext links to third-party sites or information are provided solely as a convenience to you and do not in any way constitute or imply ECR's endorsement, sponsorship or recommendation of the third party, information, product or service. ECR is not responsible for the content of these pages and does not make any representations regarding the content or accuracy of material in this file.

As per copyright regulations, any unauthorised use of the material or parts thereof as well as commercial reproduction or multiple distribution by any traditional or electronically based reproduction/publication method is strictly prohibited.

You agree to defend, indemnify, and hold ECR harmless from and against any and all claims, damages, costs, and expenses, including attorneys' fees, arising from or related to your use of these pages.

Please note: Links to movies, ppt slideshows and any other multimedia files are not available in the pdf version of presentations.

www.myESR.org
Learning objectives

The aim of this educational exhibit is to describe the main radiological features of pleuro-pulmonary, mediastinal and tracheobronchial calcifications that radiologists could find during thoracic examinations; specific localizations and recognition markers of calcifications associated with several pulmonary diseases are illustrated.
Background

Intrathoracic calcifications occur in a wide variety of disorders and they are frequently found in chest X-ray and CT examinations. They may arise in the pulmonary parenchyma, mediastinum, hilar and mediastinal lymph nodes, pleura, or any combination of these structures.¹

The calcification mechanism can occur in normal or abnormal lung parenchyma, and understanding the process can provide insight into the cause and effect. For example, a hormonal imbalance can result in an elevated serum calcium level, leading to calcium salt deposition within normal tissue. On the other hand, during the natural process of tissue destruction, dystrophic calcifications form. Neoplasms can also contain calcifications by incorporating calcified granulomas or dystrophic calcifications already present in the lung parenchyma. Finally, ossification -or the process of forming new bone- can be seen in metaplastic or malignant bone-forming cells such as metastatic osteosarcoma.²,³

Chest calcifications are often clinically asymptomatic and of benign significance, but sometimes they may represent the manifestation of a systemic pathology or a malignant process. The morphological characteristics of the calcifications, the distribution pattern, the location, and the associated clinical characteristics are fundamental for the correct diagnostic classification.
Imaging findings OR procedure details

Based on localizations and patterns of the anatomic distribution - radiologists may classify into four groups, which include pleuro-pulmonary, mediastinal and tracheobronchial calcifications. The first group is certainly reported as the most frequently encountered; more in detail, pleuro-pulmonary calcifications may appear as nodules, micronodules or masses, showing focal or diffuse distribution. Among the various etiological causes, it is important to differentiate neoplastic (primary or metastatic) and non-neoplastic forms. The latter include infectious diseases, occupational diseases, environmental exposures, accumulation disorders, pneumoconiosis, hematological and endocrinological disorders. Pleuro-pulmonary calcifications may be found in a rare idiopathic condition such as pulmonary alveolar microlithiasis. Most commonly encountered mediastinal calcifications causes include inflammatory-infectious forms, aging outcomes, cardiovascular diseases, and sarcoidosis. Tracheobronchial calcifications are mainly due to forms of aging or prolonged therapy with warfarin.

PULMONARY CALCIFICATION

Focal parenchymal calcifications

Neoplastic:

· Hamartomas

Pulmonary hamartomas are the most common benign lung neoplasm, are composed by disorganized mature mesenchymal and epithelial tissue elements and usually contain both cartilage and adipose tissue. These lesions are usually discovered on chest radiographs as a solitary pulmonary nodule in an asymptomatic adult patient. Radiographically, the tumors are typically well-circumscribed, lobulated lesions less than 4 cm in diameter, located peripherally in the lung. Hamartomas with chondromatous elements have characteristic popcorn-like calcifications that may be identified on plain radiographs. The frequency of calcification increases with tumor size, varying from 3% to 75% of lesions.¹,⁴,⁵ (Fig.1)

· Malignant neoplasm
The identification of calcifications within a pulmonary nodule is an important feature to distinguish benign and malignant nodules. It is, however, necessary to remember that calcifications can rarely appear in primary lung tumors such as small cell, squamous cell, adenocarcinoma, carcinoid, and mucoepidermoid carcinoma. Four mechanisms of calcification formation in neoplasms have been described, and include calcified scar tissue, granulomatous disease incorporated into the tumor, calcium deposits from mucinous tumor secretions, and dystrophic calcifications within necrotic tissue. The calcifications can appear in different patterns: amorphous, punctate or reticular. Ossification most often produces a reticular pattern seen most evidently in carcinoid tumor.

Non-neoplastic

- **Infectious granulomatous diseases**

Focal calcifications in the lung usually appear as the result of a healed primary granulomatous lesion. Usually, a calcified granuloma is due to histoplasmosis, less frequently to tuberculosis, and rarely to coccidioidomycosis or blastomycosis. An acute primary granulomatous infection has variable clinical and radiographic features, with manifestations dependent on the host's immune response to the presence of the organisms. The acute parenchymal process most often manifests as segmental or lobar consolidation, with or without associated hilar lymphadenopathy. In tuberculosis infections, the Ghon lesion (sometimes called Ghon focus) represents a calcified tuberculous caseating granuloma (tuberculoma) and represents the sequelae of primary pulmonary tuberculosis infection. When associated with a calcified ipsilateral hilar node it is known as a Ranke complex.

- **Parasitic diseases**

Various parasitic diseases may give rise to focal pulmonary calcifications. Echinococcosis (hydatid disease) is caused by two cestode species: Echinococcus granulosus and, less frequently, Echinococcus multilocularis. Humans become intermediate hosts after direct contact with infected animals or contaminated material. Hydatid disease of the lung most often manifests as a solitary cystic mass lesion with a lower lobe predominance, and their calcification is rare. The unruptured cysts are usually asymptomatic. Pulmonary paragonimiasis is caused by liver fluke (Paragonirnus westermani). Humans are usually infected by ingesting raw or undercooked crayfish or crab. Ring shadows, thin-walled cysts, nodular and linear areas of increased opacity, focal air-space consolidation, and pleural effusions have been described in this disease.
Calcification may develop late in the disease history. Although other parasites may cause calcification in other parts of the body, pulmonary calcification is uncommon.¹

**Diffuse parenchymal calcifications**

**Neoplastic**

- **Pulmonary metastasis**

Pulmonary metastasis containing calcifications rarely occur. Two processes of formation can be distinguished: bone forming tumors that produce numerous calcified metastases and the non-bone forming lung metastases that occasionally show calcium deposition from secondary causes. For instance, osteosarcoma and chondrosarcoma exhibit the process of ossification and calcification by their respective malignant cells, mucin-producing tumors deposit mucoid calcifications. Rarely, papillary thyroid cancer can display dystrophic calcifications. Other reported causes include germ cell tumor of bone, synovial sarcoma, and treated metastasis from choriocarcinoma. By identifying the amount of calcification within the lung metastasis and the patient's history, one can differentiate bone-forming metastasis due to osteosarcoma and chondrosarcoma from other etiologies.¹,²,⁴,⁵

**Non-neoplastic**

- **Metastatic calcinosis**

Metastatic pulmonary calcification is a misnomer: it is not related to cancer widespread, but caused by deposition of calcium salts within normal lung parenchyma during states of hypercalcemia. This condition may be seen in patients with chronic renal failure, hyperparathyroidism, multiple myeloma, intravenous calcium therapy, hypervitaminosis D, milk-alkali syndrome and sarcoidosis. (Fig.2)

There is a predominant involvement of the upper lobes where relatively high ventilation-perfusion ratios promote a more alkaline environment which reduces the solubility of calcium. Centrilobular amorphous calcifications of 3-10 mm in size are observed within ground-glass opacities that can also form into a calcified consolidation. The effects can be reversed with treatment of the underlying cause of hypercalcemia.¹,²

- **Occupational pneumoconiosis**
Occupational pneumoconiosis includes silicosis and coal workers’ pneumoconiosis, and less commonly tin oxide (stannosis), iron oxide (siderosis), barium dust (baritosis), beryllium (berylliosis). Silicosis is caused by inhalation of free silica particles, usually during occupational exposure such as mining, sandblasting, and masonry. Radiographic abnormalities due to silicosis usually occur after a latency period of 10-20 years after exposure. The characteristic radiographic feature is small, nodular areas of increased opacity that can occasionally calcify. Pathologically, these nodules represent peribronchiolar accumulations of dust with associated fibrosis. Complicated silicosis is characterized by the development of large masses, 1 cm or greater in diameter, produced by coalescence of the small nodules. As these conglomerate lesions develop, they converge toward the hila, leaving emphysematous spaces peripherally. Patients with this disorder experience severe respiratory impairment. On chest radiographs, silicotic nodules appear as small, randomly distributed nodules that are most prominent in the middle and upper lung zones. Central calcification of the pulmonary nodules occur in 5%-10% of cases and may be subpleural. Hilar and mediastinal lymphadenopathy is frequent, and nodes may calcify circumferentially in an eggshell pattern in up to 5% of patients. Although initially thought to be pathognomonic for silicosis, an eggshell distribution of nodal calcification has also occasionally been described in sarcoidosis, histoplasmosis, blastomycosis, scleroderma, and amyloidosis.\textsuperscript{1,2} (Fig.3-4-5)

\textbf{· Amyloidosis}

Amyloidosis is a disease complex resulting from extracellular deposition of insoluble fibrillar proteinaceous material. The disease occurs in middle-aged and elderly patients and affects men more often than women. The majority of cases of amyloidosis occur concomitantly with other diseases, like multiple myeloma, other plasma cell dyscrasias, or inflammatory processes. Instead, approximately 10% of cases are primary or hereditary. Respiratory involvement occurs in about half of the patients with amyloidosis; however, it is usually radiographically occult. On radiographs, pulmonary amyloidosis is evident in three major forms: tracheobronchial, nodular, and diffuse parenchymal. The tracheobronchial form is generally characterized by multiple nodules protruding into the tracheal and bronchial wall, causing bronchial obstruction with collapse and air trapping. Radiographically, tiny calcific areas of increased opacity has seen within the tracheal or bronchial walls. Nodular pulmonary amyloidosis is characterized by multiple round or oval, sharply defined areas of increased opacity of variable size and number. Approximately 50% of the nodules calcify or ossify. The diffuse parenchymal form appears as a nonspecific, diffuse interstitial process, which may occasionally become confluent or progress to honeycombing.\textsuperscript{1}

\textbf{· Varicella Pneumonia}
Varicella is a highly contagious viral illness transmitted by air droplets. The frequency of varicella pneumonia increases significantly with age, and 75% of cases of varicella pneumonia occur in the 3rd-5th decades of life. Patients with hematological diseases (particularly leukemia and lymphoma), those taking corticosteroids or antibiotics, and pregnant women have a higher mortality risk from varicella pneumonia. Healed varicella pneumonia is characterized radiographically by micronodular calcifications, with 1-2 mm diameter spherical nodules distributed bilaterally. Sometimes, a single larger lesion may be identified. The number of nodules varies from a few scattered lesions to over a hundred lesions, and the number of nodules and the density of the calcifications may increase within time. Radiographically, the appearance of healed varicella may mimic that of healed histoplasmosis, with multiple tiny calcified pulmonary nodules. Associated calcified mediastinal nodes and calcified hepatic and splenic micronodules make histoplasmosis the more likely diagnosis.

- **Pulmonary alveolar microlithiasis**

Pulmonary alveolar microlithiasis is a rare condition of unknown pathogenesis that causes the formation of intra-alveolar microcalcifications (calcispherytes), containing calcium phosphate, which appears as scattered micronodular calcifications often recognized as "sand-like", mostly in the middle and lower lung zones. They normally occur within areas of ground glass opacities that can form a crazy paving pattern. Despite this, patients typically have normal serum calcium and phosphorus levels. In many patients, the disorder is clinically occult for a long period of time and it is incidentally detected on chest radiographs performed for other reasons. The calcifications are denser and more numerous along the bronchovascular bundles causing interlobular septal thickening, and in the subpleural regions predisposing to a pneumothorax. With the progression of the disease, interstitial fibrosis and subpleural cysts may be found. Differentiation from other forms of calcification is based on the characteristic radiographic features and the paucity of clinical symptoms relative to the massive pulmonary involvement.

- **Pulmonary Ossification**

Diffuse pulmonary ossification is a rare condition caused by metaplasia of fibroblasts into osteoblasts by a chronic insult. The pathophysiology is uncertain, but it is thought that transforming growth factor-beta (TGF-beta) is elaborated from inflammatory cells at the site of tissue injury and promotes metaplastic bone formation and fibroblastic proliferation instead of healing. Pulmonary ossification occurs in the presence of repeated lung injury, in association with such disorders as interstitial fibrosis, recurrent bronchopneumonia, and pulmonary edema. There are two types of pulmonary ossification: dendriform (which branches along terminal airways) and nodular (in which well-circumscribed areas of
mature bone are present within the alveolar spaces). The ossification occurs bilaterally in the peripheral subpleural lower lungs. The dendriform pulmonary ossification type appears as <2mm microcalcifications in a linear branching, tree-in-bud pattern that is often a component of advanced idiopathic pulmonary fibrosis and therefore follows a similar pattern of distribution. The nodular pulmonary ossification type consists of similar to slightly larger microcalcifications that may aggregate into larger masses or pseudo-plaques and is seen with chronic pulmonary venous hypertension and in some patients with mitral stenosis. Pulmonary ossification can often be found as an incidental radiologic finding with minimal clinical significance but should be recognized and differentiated from other entities. \(^{1,2}\) (Fig.6)

**PLEURAL CALCIFICATION**

Pleural calcification can occur following a variety of pleural injuries that culminate in pleural thickening and fibrosis, including empyema, hemothorax, and exposure to the fibrogenic dusts asbestos and talc; it occasionally occurs after therapeutic pneumothorax performed for tuberculosis. We also need to remind that oleothorax-intrapleural or extrapleural injection of oil used in the past for treatment of tuberculosis can result in large calcified pleural collections. The calcifications normally affect the visceral pleura, except in cases of inorganic dust exposure. The process is usually unilateral and frequently results in volume loss in the affected hemithorax and subsequent fibrothorax. When the plaques are unilateral should be considered the possibility of pleural metastasis, most commonly due to osteosarcoma. Calcified pleural plaques resulting from exposure to asbestos or talc typically develop 20 years or more after exposure, with the extent of calcification progressing over time. In contrast to post-inflammatory pleural calcification, asbestos-related plaques involve the parietal pleura and are usually bilateral. Radiographically, the plaques appear as sharply marginated, linear calcifications when viewed in profile and as faint. They are most prominent along the diaphragmatic surfaces and the lower half of the thorax between the sixth and ninth ribs. Less commonly, plaques occur in the upper thorax and along the cardiac border. It is also important to remind that localized fibrous tumors of the pleura may contain focal calcification, but these tumors have no relation to asbestos exposure. \(^{1,2}\) (Fig.7-8)

**MEDIASTINAL CALCIFICATION**

Nodal calcification

- *Sarcoidosis*
Sarcoidosis is an idiopathic multisystemic disease characterized by widespread non-caseating granulomas. Pulmonary parenchymal sarcoidosis originates in the pulmonary interstitium, and mediastinal and hilar lymph nodes are diffusely replaced by granulomas. Although the classic chest radiographic appearance of sarcoidosis includes right paratracheal and bilateral hilar lymphadenopathy, CT has demonstrated that any intrathoracic nodal chain can be involved. Pulmonary parenchymal sarcoidosis commonly manifests in reticulonodular, air-space, or nodular forms. Mediastinal lymph node calcification is relatively uncommon in sarcoidosis, with the reported frequency varying from 3% to 10% (38). Calcification occurs in diseased nodes and is of the dystrophic type, appearing punctate, amorphous, or popcorn like; circumferential or eggshell calcification occurs infrequently. Small miliar pulmonary calcifications are rare.¹

Vascular calcifications

Very common is the finding of vascular calcifications of the aortic and coronary vessels due to atherosclerosis processes, more commonly observed in elderly patients. These calcifications are often circumferential and can lead to a reduction in the vessel size. It is also possible to find areas of opacity due to the presence of vascular and valvular prostheses. (Fig.9-10-11)

Cardiac calcifications

It is possible to find the presence of pericardial calcifications following inflammatory processes, therefore these patients often have a history of pericarditis. Radiographically, the location of the calculations can help differentiate pericardial calcifications from myocardial calcifications caused by ventricular aneurysms. While pericardial calcification is seen more commonly over the right ventricle, myocardial calcifications are seen more commonly over the left ventricle.⁶ (Fig.12)

TRACHEOBRONCHIAL CALCIFICATION

The accidental radiological finding of calcifications of the bronchial and tracheal walls represent a common finding and usually have benign significance. Usually, these calcifications are determined by aging and are commonly found in elderly patients. Patients are generally asymptomatic. Long-term warfarin therapy may also cause calcifications of the trachea and bronchi, probably because warfarin prevents the formation of vitamin K-dependent proteins that are responsible for preventing calcification.⁷ (Fig.13)
**Fig. 1:** Hamartoma. High-resolution CT scan of two different patients demonstrates a focal region of calcification within a well-circumscribed nodule respectively in right and left lung.

© Radiology Unit I - Department of Medical and Surgical Sciences and Advanced Technologies "G. F. Ingrassia" - University of Catania - Catania/IT

**Fig. 2:** Sarcoidosis. High-resolution CT scan of a patient with sarcoidosis show a calcified nodule in left lung.

© Radiology Unit I - Department of Medical and Surgical Sciences and Advanced Technologies "G. F. Ingrassia" - University of Catania - Catania/IT
Fig. 3: Silicosis. High resolution CT scan shows right hilar lymphadenopathies with nodes calcified.
**Fig. 4:** Berylliosis. The high-resolution CT scan (mediastinal window) shows areas of consolidation with a retraent appearance within calcifications and bronchioloectasis.

© Radiology Unit I - Department of Medical and Surgical Sciences and Advanced Technologies "G. F. Ingrassia" - University of Catania - Catania/IT

**Fig. 5:** Occupational exposure pneumoconiosis. CT scans show multiple small nodular formations, some of which are calcified, with random distribution in lung parenchyma, with prevalent localization at the upper lobes and apical segments of the lower lobes.

© Radiology Unit I - Department of Medical and Surgical Sciences and Advanced Technologies "G. F. Ingrassia" - University of Catania - Catania/IT
**Fig. 6:** UIP (Usual Interstitial Pneumonia) with ossification. High-resolution CT scans show dendritic pulmonary ossification in a patient with UIP.

© Radiology Unit I - Department of Medical and Surgical Sciences and Advanced Technologies "G. F. Ingrassia" - University of Catania - Catania/IT

**Fig. 7:** Calcified pleural plaques. Chest X-ray in the antero-posterior and lateral projections shows calcified plaque of the margino-costal pleura at left lateral costophrenic angle.

© Radiology Unit I - Department of Medical and Surgical Sciences and Advanced Technologies "G. F. Ingrassia" - University of Catania - Catania/IT
**Fig. 8:** Calcified pleural plaques. CT scans of a patient with asbestos exposure show multiple bilateral calcified pleural plaques.

© Radiology Unit I - Department of Medical and Surgical Sciences and Advanced Technologies "G. F. Ingrassia" - University of Catania - Catania/IT
**Fig. 9:** Calcification of aortic arch and cardiac valve prosthesis. Chest X-ray in the antero-posterior and lateral projections show a circumferential calcification of the aortic arch and an area of cardiac opacity due to the presence of valve prosthesis.

© Radiology Unit I - Department of Medical and Surgical Sciences and Advanced Technologies "G. F. Ingrassia" - University of Catania - Catania/IT

**Fig. 10:** Calcification of the aortic anulus. CT scans show calcifications of the aortic annulus.

© Radiology Unit I - Department of Medical and Surgical Sciences and Advanced Technologies "G. F. Ingrassia" - University of Catania - Catania/IT
Fig. 11: Coronary artery calcifications. CT scans show calcifications of the coronary arteries.

© Radiology Unit I - Department of Medical and Surgical Sciences and Advanced Technologies "G. F. Ingrassia" - University of Catania - Catania/IT
**Fig. 12:** Pericardial calcification. CT scans show calcification of the lower side of the pericardium.

© Radiology Unit I - Department of Medical and Surgical Sciences and Advanced Technologies "G. F. Ingrassia" - University of Catania - Catania/IT
**Fig. 13:** Calcifications of the trachea and bronchial walls. CT scans show diffuse calcifications of the walls of the trachea and bronchi bilaterally.

© Radiology Unit I - Department of Medical and Surgical Sciences and Advanced Technologies "G. F. Ingrassia" - University of Catania - Catania/IT
Conclusion

Calcifications are frequent findings that radiologists may observe on chest X-ray or thoracic CT examinations; they may be associated with a wide variety of underlying causes. Therefore, their evaluation at imaging should be based on clinical history, distribution, and appearance, in order to distinguish between the malignant forms and those for which further diagnostic investigation is not necessary.
References


