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Interpreting chest radiographs in the elderly – A clinician's guide

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ABSTRACT

With the global rise in life expectancy, mainly attributed to advances in medical sciences, the geriatric population is on a continuous rise. The concept of ageing is changing today with major aim being increasing the quality of longevity, rather than just the years of life. As a result, the elderly are subjected to numerous diagnostic procedures including imaging, the most common being chest radiography. Interpretation of chest radiographs in the elderly is a challenging task given that certain alterations from normal occur as a result of ageing-related physiological changes which closely mimic and need differentiation from pathological findings. These are mainly related to the patients themselves because of their frailty, immobility, inability to hold breath for long, poor inspiratory effort leading to motion artefacts and presence of comorbidities (previous surgery, hypertension, renal insufficiency, poor peripheral venous access etc). A clinician needs to be familiar with the normal expected paraphysiological changes and correlate them with clinical findings to arrive at a reasonable diagnosis and administer appropriate management.

The ageing-related changes in chest can be broadly classified into those occurring in chest wall, mediastinum and lung parenchyma respectively. Through this article, we have tried to bring out certain frequently encountered ageing related changes in chest imaging and clinical clues to distinguish the same from pathological changes.

Keywords: Chest radiograph; Geriatric population; Ageing-related changes in thorax.

INTRODUCTION

The current era of medicine and advanced therapeutics has witnessed a substantial upsurge in life expectancy with more people entering the geriatric age group. As per the WHO global health observatory data, global life expectancy at birth in 2016 was 72.0 years (74.2 years for females and 69.8 years for males), ranging from 61.2 years in the WHO African Region to 77.5 years in the WHO European Region.[1] With rising prevalence of elderly in the community, they undergo various investigations and imaging regularly to sustain a disease free life. However, in these patients, it can at times become challenging for the physician to interpret the result findings and distinguish it between the ageing process and the disease itself.[2,3] Chest imaging, a commonly used modality, is a pandora's box which gives immense information about soft tissues, bones, respiratory system and the cardiovascular health of an individual. However, chest imaging in elderly requires a specific knowledge. Major glitches faced are related to the patients themselves because of their frailty, immobility, inability to hold breath for long, poor inspiratory effort leading to motion artefacts and presence of comorbidities (previous surgery, hypertension, renal insufficiency, poor peripheral venous access etc).[4] Also, in particular are the physiological changes seen in elderly X rays and CT scans of chest due to ageing process, with which if

one is not familiar can lead to unnecessary work up and waste of diagnostic resources.

To obviate the technical difficulties, chest imaging in these patients should be based on strategies, such as chest radiography and CT, that allow to obtain information with few or no changes in positioning. Moreover, the last generation CT allow to acquire the entire lung volume in few seconds (3 sec about) avoiding artefacts due to breath holding. When faster CT scanner are not available other strategies to reduce these motion artefacts include the caudal start of the scan and the use of a higher pitch.[5] The objective of the present article is to describe the most common aging-related chest imaging findings. For the ease of understanding, the various ageing related changes have been broadly classified into three major sub-headings, namely those related to chest wall, mediastinum and lung parenchyma respectively.[6] [Table 1]

RADIOLOGICAL FINDINGS RELATED TO AGEING IN CHEST WALL

The progressive ageing-related changes leads to an altered X-ray image leading to significant difficulty in interpretation if one is not verse with the normal physiological findings occurring with age. The ageing is a universal ongoing process involving each cell of human body, thereby affecting all structures including spine, soft tissue, bony cage, lungs and cardiovascular structures.

- Dorsal spine

• Osteoporosis: Osteoporosis, defined as a reduction in the strength of bone, is one of the most common findings consistent with ageing. It is more commonly seen in women and leads to a reduction in vertebral radiolucency.[7] [Fig. 1]

• Spondylosis, kyphosis and vertebral soma height reduction: Spondylosis denotes the various degenerative changes of the spinal column which include abridged intervertebral space, sclerosis of bone adjacent to the intervertebral discs, and marginal vertebral osteophytes. Overall, vertebral osteophytes are more frequently observed on the right side of the spinal column, due to the presence of the descending aorta on the left side. The presence of dorsal kyphosis with a more convex sternum leads to the so-called “barrel chest” deformity, a phenotypic configuration of the chest in elderly individuals. These changes when combined lead to restricted motion of the chest wall, thereby having an adverse bearing on respiratory mechanics.[8-10] [Fig. 2,3]

• Barrel chest: is described as a marked dorsal kyphosis with a more convex sternum leading to an increase in the antero-posterior diameter of the thorax. This is accompanied by atrophy of chest wall muscles. The deformity due to ageing needs to be differentiated from that due to chronic obstructive pulmonary disease (COPD). The diagnosis of COPD should be considered in priority in presence of additional findings such as pulmonary emphysema, bronchial wall thickening and bronchiectasis. However, the definitive diagnosis requires lung function tests.[11-14] [Fig. 4]

- Ribs

• Costochondral calcifications, costovertebral and costosternal osteoarthrosis: Additional common finding is costal cartilage calcification, visualised on X-ray as small islands of compact bone tissue. The same needs to differentiated from solitary pulmonary nodules, nature of which can be definitely elicited by CT scan. [Fig. 5-7]

- Diaphragm

• Diaphragm bump and diaphragmatic hernia: Other findings in the elderly include diaphragmatic bulging due to muscle hypertrophy and dyskinesia in some areas, predominantly on the right side, possibly caused by the extra effort of the right hemidiaphragm to maintain the anatomical relationship between the lung and the liver. This finding is clinically significant as it needs to be differentiated from subpulmonic pleural effusion. Subtle signs in favour of later include elevation of the hemidiaphragm with a peak more lateral than usual and non-visibility of lung vessels through the hemidiaphragm.[15] [Fig. 8-10]

- Muscles

• Atrophy of the chest wall muscles: is due to age-related reduction in the thickness of the parietal muscles and leads to an increased pulmonary transparency on chest X-rays in elderly. Weakness of intercostal muscles may also seldom cause focal herniation of lung parenchyma through the intercostal space.[15] [Fig. 11-12]

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RADIOLOGICAL FINDINGS RELATED TO AGEING IN MEDIASTINUM

The physicians also routinely encounter certain changes in chest radiograph in the geriatric population that are solely attributed to cardiac ageing. This specific group of individuals are characterized by radiological findings that are not related to common comorbidities found in elderly, namely, hypertension, obstructive pulmonary disease, atherosclerosis, diabetes and renal failure.

- Heart

• Cardiac enlargement: One of the most frequently encountered physiological change related to cardiovascular ageing is enlargement of left ventricle. This occurs due to an increase in myocardial mass, with a slight hypertrophy of myocytes and an increase of the connective tissue component. These changes generally denote the clinical spectrum of age-related diastolic dysfunction and can occasionally contribute to decompensation in cases of cardiac overload due to external factors, resulting in a reduction of the functional reserves. However, they need to differentiated from pathological causes of cardiac enlargement including hypertensive or dilated cardiomyopathy.[16,17] [Fig. 13]

• Valve calcifications: The age-related deposition of fat, collagen and calcium salts can lead to thickening of heart valves and wearing of valve annulus, characteristic of normal cardiovascular ageing. Thickening of the valvular margins may at times result in mild mitral valve insufficiency, a feature noted in 90% percent of patients with more than eighty years old.[18] [Fig. 14-15]

• Coronary calcifications: Attributed to the process of ageing with a similar physiological basis as described above, the coronaries undergo sclerosis, possibly leading to alterations in myocardial perfusion. Also, studies in the geriatric population strongly support the fact that calcification of the thoracic aorta, heart valves, and coronary arteries predispose these individuals to a higher risk of cardiovascular diseases. These changes are better appreciated on chest CT images and generally warrant a coronary angiography to delineate if the calcifications are an expression of the natural aging process or whether there are atheromatous plaques with significant stenosis and a reduction of cardiac perfusion.[19,20] [Fig. 16]

- Aorta

• Parietal calcifications: Atherosclerotic calcification of the aorta is another frequent incidental finding noted on chest x-rays done for other reasons. They are most commonly seen in aortic arch and descending thoracic aorta and are not always pathologically significant. However, being an independent cardiovascular risk factor, they should be reported and considered while instituting therapy.[20] [Fig. 17]

• Enlargement and tortuosity: Other changes in aorta including elongation and dilatation, a result of repeated mechanical stimuli and elastic connective tissue reduction of the aortic wall, are a common cause of enlargement of the mediastinal contour in chest radiograph frontal projection. These changes need to be distinguished from the more serious pathologies like aneurysmal dilatation of aorta, which essentially requires a CT angiogram.[21] [Fig. 18]

- Trachea/bronchi

• Chondral calcifications: Though, frequently seen in chest radiographs of elderly, they are generally benign and do not represent a pathological finding.[21] [Fig. 19]

RADIOLOGICAL FINDINGS RELATED TO AGEING IN LUNG PARENCHYMA

The lungs are a vital organ of human body, constantly working to provide essential gas exchange to sustain life. The lungs grow and develop through the first two decades of life reaching maturity by approximately 20 years of age in females and 25 years of age in males. With ageing, lung function gradually declines due to disequilibrium triggered by changes in ventilation/perfusion ratio.[22,23] These changes, however do not cause clinically significant morbidity unless affected by an underlying disease.

- Lung parenchyma and vessels

Reticular interstitial thickening and lamellar atelectasis: The physiologic ageing process of the lung is characterized by alteration at both macroscopic and microscopic level. As already discussed, macroscopic alterations are due to rib cage deformity, the so called "barrel chest". In addition, microscopic changes occurring at cellular level are

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characterized by an increase of the connective tissue, reduction of lung elasticity with subsequent distal airways collapse and increase in residual volume. Studies conducted on variation in collagen and elastin content with ageing, however summarize that the total collagen and elastin content does not increase with age. Rather, the lung elastic recoil is lost due to changes in spatial arrangement of the network of collagen fibres. During the ageing process, the alveolar ducts increase in diameter and the alveoli become bigger and shallower. Subsequently, elastic fibres in the respiratory bronchioles and alveoli degenerate thereby decreasing their compliance. The whole series of changes leads to alveolar duct dilatation and homogenous air space enlargement. This mechanism is analogous to that of pulmonary emphysema with three major differences: no signs of alveolar septa destruction, no inflammation and no increase in total pulmonary capacity. In view of almost similar morphostructural changes with no underlying disease, the age-related changes in lung parenchyma are also referred to as "senile emphysema". Finally, ageing also results in reduction of number and calibre of the vessels and the capillary bed with subsequent reduction in optimal gas exchange thereby leading to decreased arterial oxygenation and pulmonary hypoperfusion. Moreover, physiological ageing of lung parenchyma can lead to development of subtle degrees of pulmonary hypertension.[24-28]

The visual connotations of these changes on chest radiograph include a "barrel chest" with an increased bilateral hyper-lucency and homogeneous reduction of vascularization (differential diagnosis with emphysema in which there is a dis-homogeneous reduction of vascularization), bronchial wall thickening and air bubbles. These changes can be better seen on computed tomograms where they are characterized by a reticular pattern with thickening of interlobular and intralobular septa, cysts, bronchial dilatation and bronchial wall thickening.[29-31] [Fig. 20, 21]

CONCLUSION

In the world of evidence-based medicine today, it is extremely crucial to be well versed with normal paraphysiological ageing related changes and to differentiate them from other pathological conditions. This can avoid to a great extent, further unnecessary diagnostic and pharmacological interventions, thereby reducing unwarranted therapy and financial burden in the geriatric population. However, easier said than done, there is a considerable gray zone in this regard. For instance, it has been recently suggested that smoking-related fibrotic alterations are nothing more than an acceleration of aging processes, mediated by oxidative chronic damage.[32]

It is extremely important to understand the fact optimal functioning of human body requires a perfect balance between two vital pumps in the chest, the cardiac and the pulmonary. Besides the normal physiological aging modifications that must be recognized, not to be interpreted erroneously as pathologies, we know that older patients become ill more frequently and so the functional insufficiency of one pump inevitably has consequences for the other. If the older patient develops a chronic obstructive pulmonary disease (COPD) this results in an increase in vascular resistance, pulmonary arterial hypertension, involvement of the right heart and limitation of heart movements due to lung expansion. On the other hand, if the patient develops a pulmonary edema this is associated with a left cardiac insufficiency, cardiomegaly, pulmonary venous hypertension and a restrictive spirometric pattern.[33-35]

A prudent clinician with knowledge needs to always weigh his choices considering both sides of the coin. We recommend a case-based approach rather than blanket guidelines when it comes to interpreting chest radiograms of elderly population. This brings us to the well-known Hippocratic principle of "primum non nocere" (above all, do no harm), which is increasingly true today, given the various choices of procedures and the increase in survival of the population.

TABLES

Table 1: Changes related to the ageing process involving chest wall, mediastinum and lung parenchyma.

Chest Wall	Dorsal spine	• Osteoporosis • Spondylosis, Kyphosis

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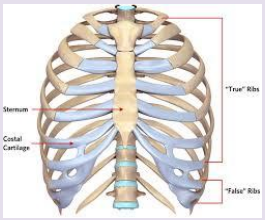
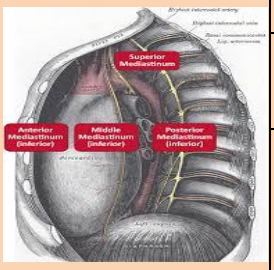
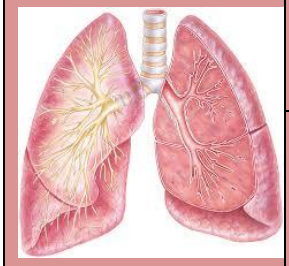
		• Barrel chest • Vertebral soma height reduction
	Ribs	• Costochondral calcification • Costovertebral and costosternal osteoarthrosis
	Diaphragm	• Diaphragm bumps • Diaphragmatic hernia
	Muscles	• Atrophy of the chest wall muscles
Mediastinum 	Heart	• Cardiac enlargement • Valve or coronary calcifications
	Aorta	• Parietal calcifications • Enlargement and tortuosity
	Trachea/Bronchi	• Chondral calcifications
Lung 	Bronchi/Bronchioles/Parenchyma	• Non specific bronchial wall thickening • Lamellar atelectasis • Reticulo-interstitial thickening • Elastic component reduction
	Vessels	• Reduction of number and caliber

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FIGURES

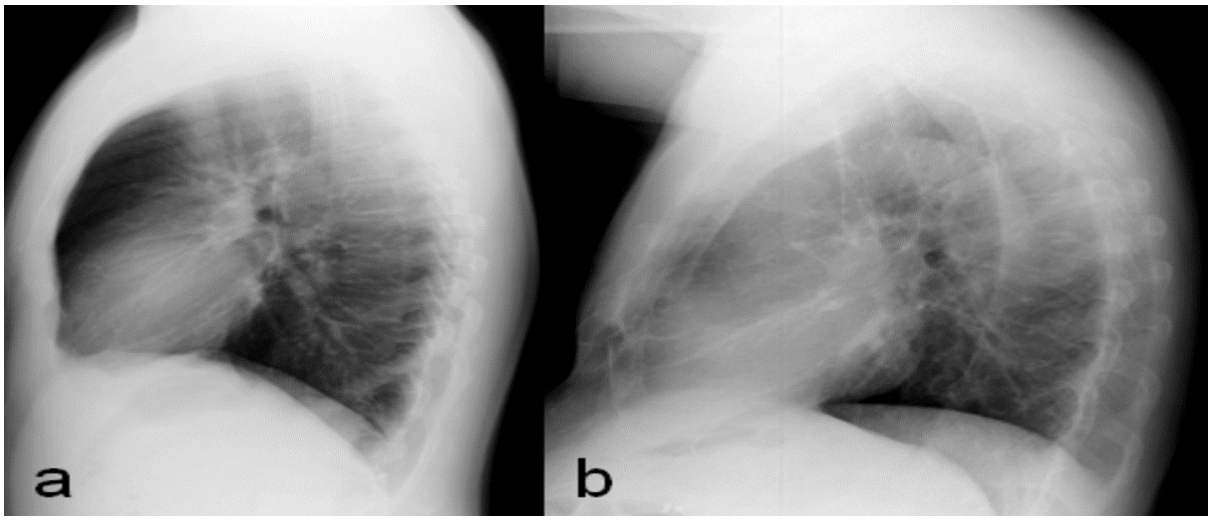

Fig. 1: Lateral chest X-ray in a 30-year-old man (a) and in an 81-year-old man (b). In figure b is evident the radiolucency of vertebral bodies due to osteoporosis.
RADIOLOGIA, OSPEDALE SS. ANNUNZIATA - Chieti/IT

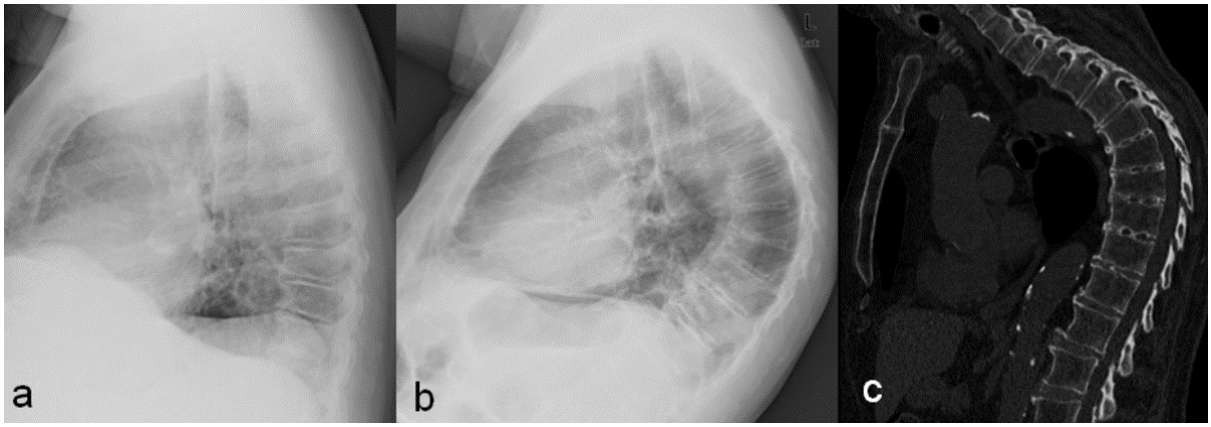

Fig. 2: Lateral chest X-ray (a) in a 73-year-old man shows reduced intervertebral space, bone sclerosis adjacent to the intervertebral discs, and marginal vertebral osteophytes with minimal height reduction of vertebral bodies. Lateral chest X-ray (b) and sagittal MPR reconstruction (c) in a 75-year-old man show more prominent degenerative changes of the spinal column with marked kyphosis.
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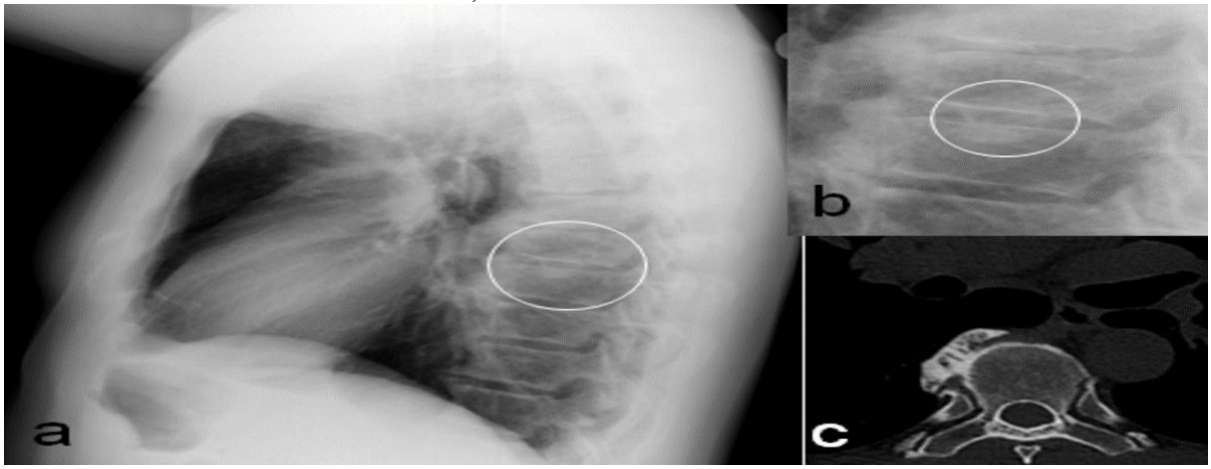

Fig. 3: The chest radiograph in lateral projection (a) and magnification (b) show a doubtful pulmonary nodular lesion projecting against the spinal column (white circles). CT scan (c) subsequently performed reveals the degenerative nature of the radiographic finding.
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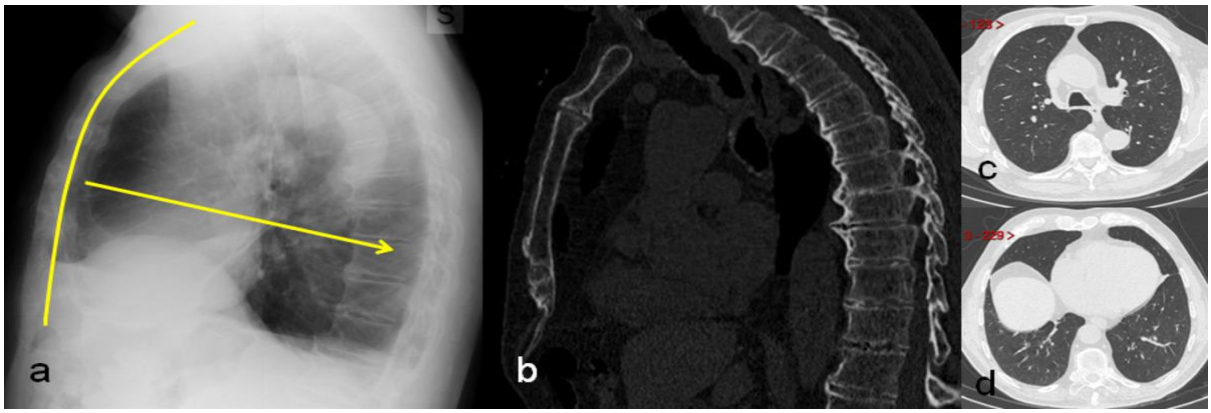

Fig. 4: Lateral chest X-ray (a) and MPR sagittal reconstruction (b) show a "barrel chest" deformity with increase in the antero-posterior diameter (yellow arrow in a). In this patient chest CT scans (c, d) subsequently performed don't show any signs of pulmonary emphysema.
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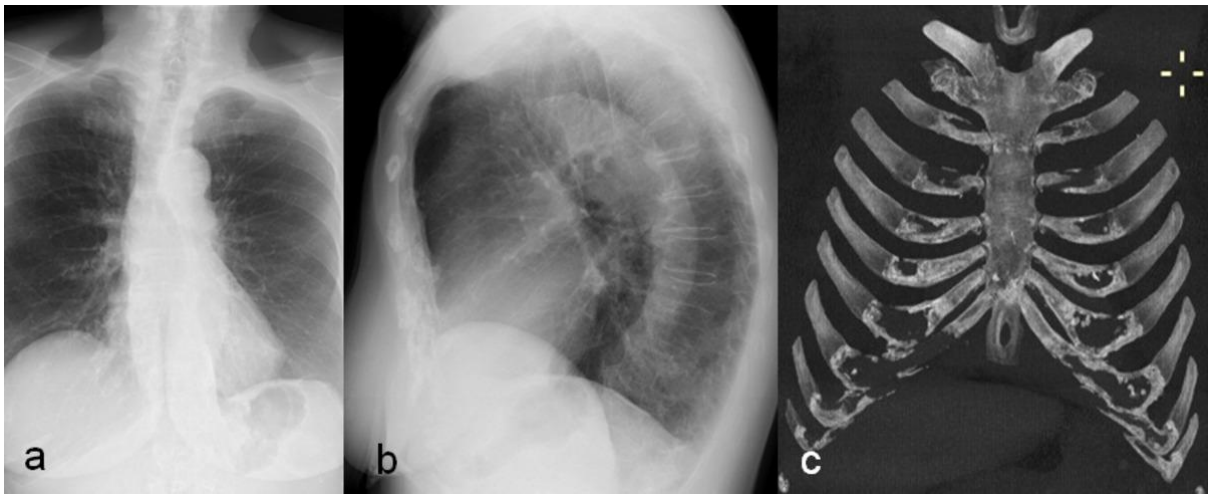

Fig. 5: Chest X-ray (a, b) in an 82-year-old woman showing fairly widespread costochondral calcification. MIP reconstruction (c) confirms the presence of the diffuse chondral calcification. RADIOLOGIA, OSPEDALE SS. ANNUNZIATA - Chieti/IT

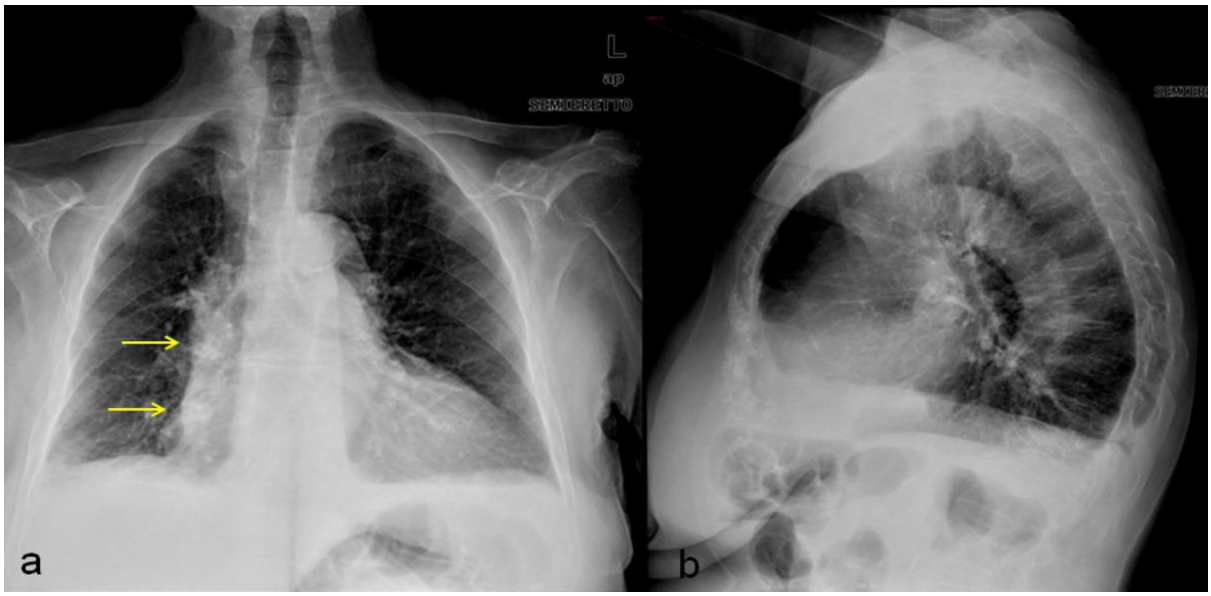

Fig. 6: Chest X-ray (a, b) showing focal opacities in the right parasternal region (yellow arrows) substained by focal costo-chondral calcification.
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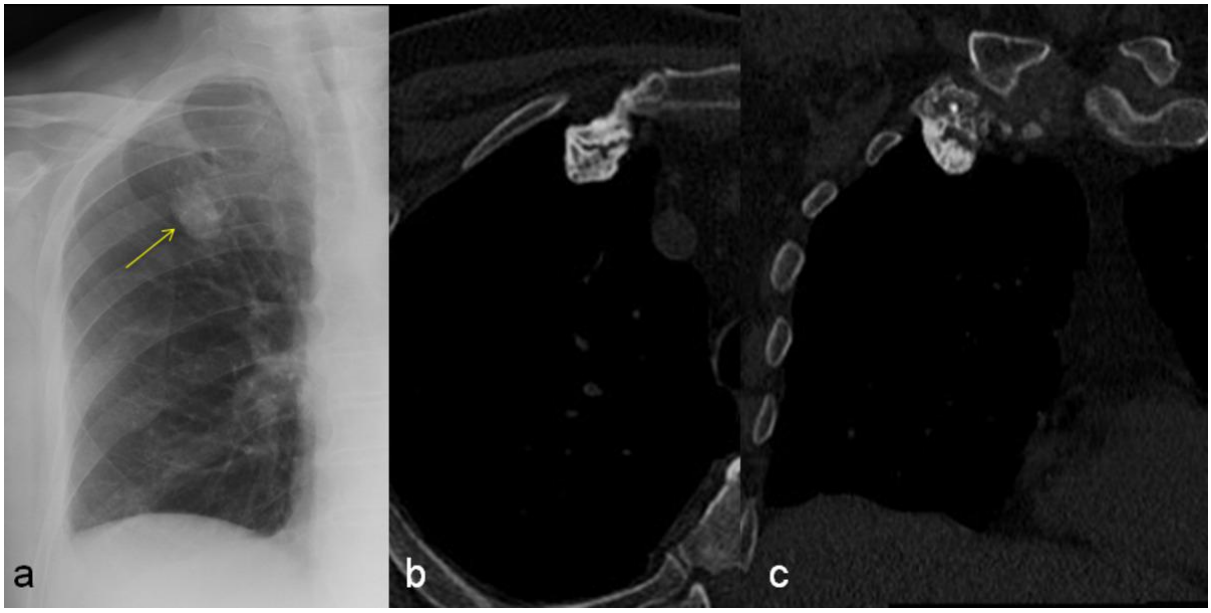

Fig. 7: Frontal chest X-ray (a) shows a right infraclavicular well-defined round opacity (yellow arrow). CT scan (b) and coronal MPR reconstruction (c) demonstrate that the radiographic opacity is consistent with arthrosis of the first costo-sternal joint.
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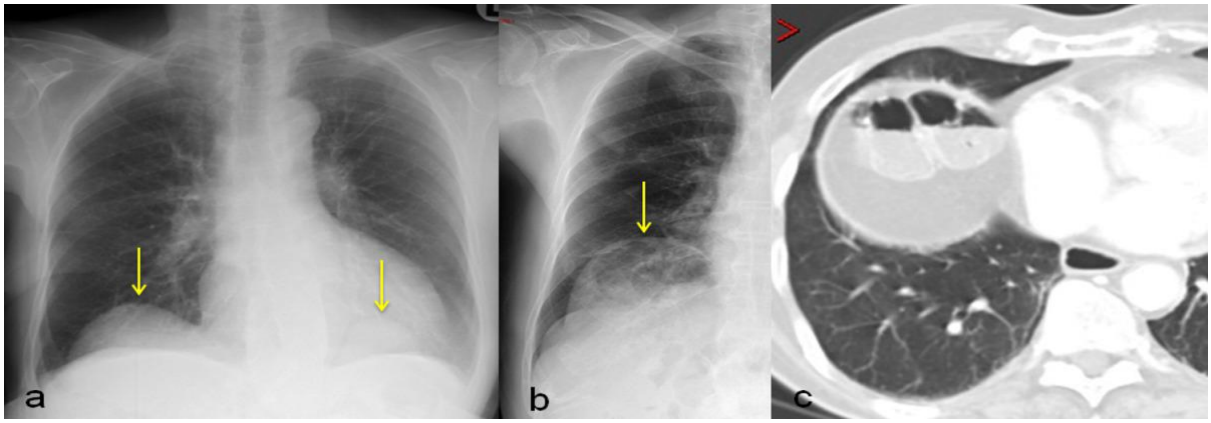

Fig. 8: Frontal chest X-ray (a) showing diaphragmatic bumps on both side (yellow arrows). Frontal chest X-ray (b) and CT scan (c) demonstrate a bulging and hyper elevation of the right hemidiaphgram.
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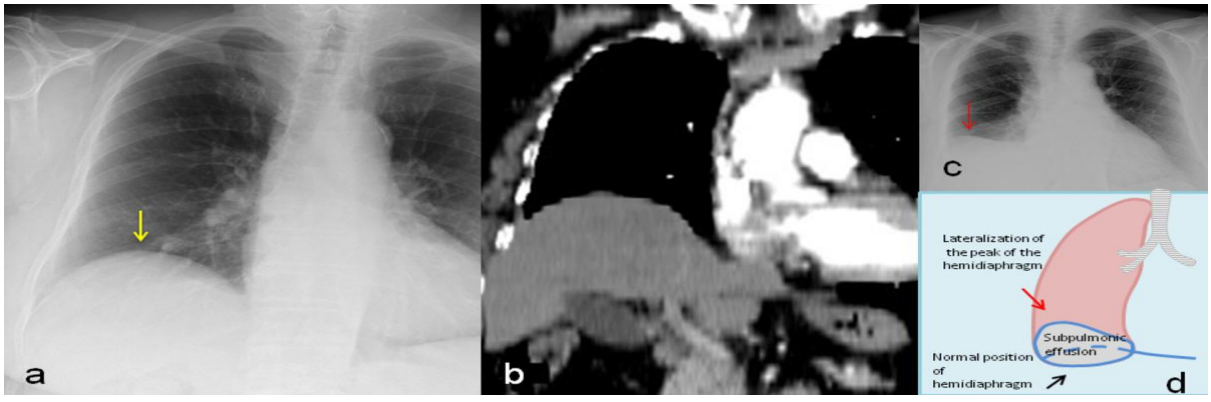

Fig. 9: Frontal (a) chest radiograph and coronal MPR reconstruction (b) in an 83-yearold woman showing elevation of the right hemidiaphragm (yellow arrows in a,b). Figure (c) and the scheme (d) show radiological findings of subpulmonic pleural effusion; in subpulmonic pleural effusion there is an apparent elevation of the right hemidiaphragm with a peak more lateral than usually (red arrows).
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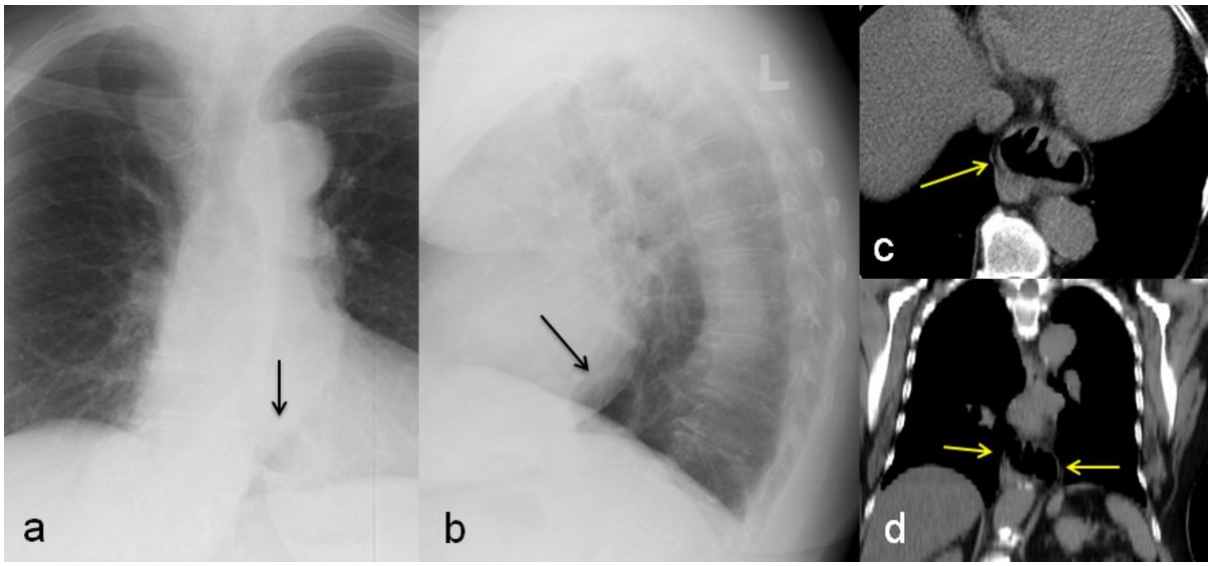

Fig. 10: Frontal (a) and lateral (b) chest X-ray in a 77-year-old woman showing a radiolucency area in the lower middle mediastinum. CT scan (c) and coronal MPR reconstruction (d) demonstrate that the radiographic finding is consistent with a hiatal hernia (arrows).
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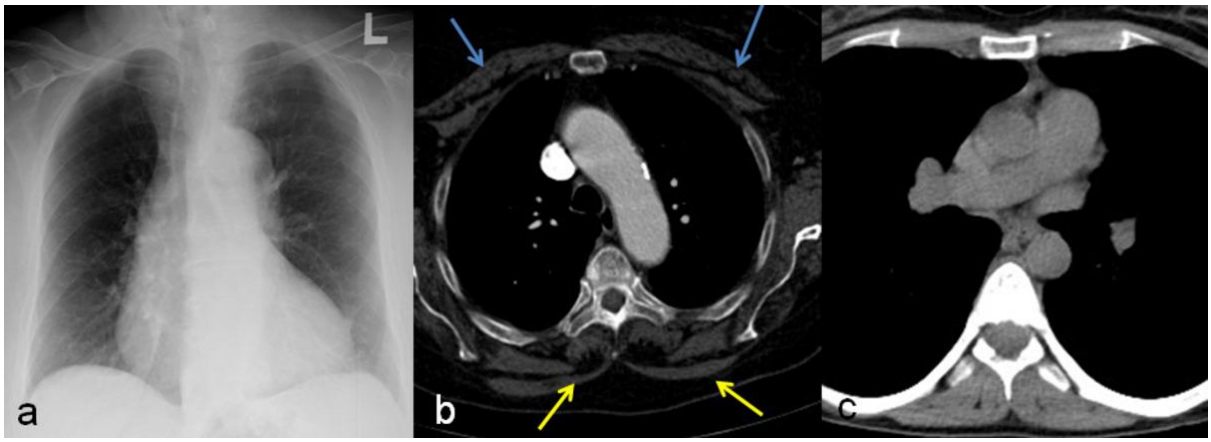

Fig. 11: Frontal chest X-ray (a) in a 73-year-old woman showing an apparent increase in lung transparency. CT scan (b) shows muscular atrophy of pectoral muscles (light blue arrows) and posterior wall muscles (yellow arrows), responsible for hyperlucency of lung parenchyma. CT scan (c) in a 38-year-old woman shows good tropism of the parietal muscles.
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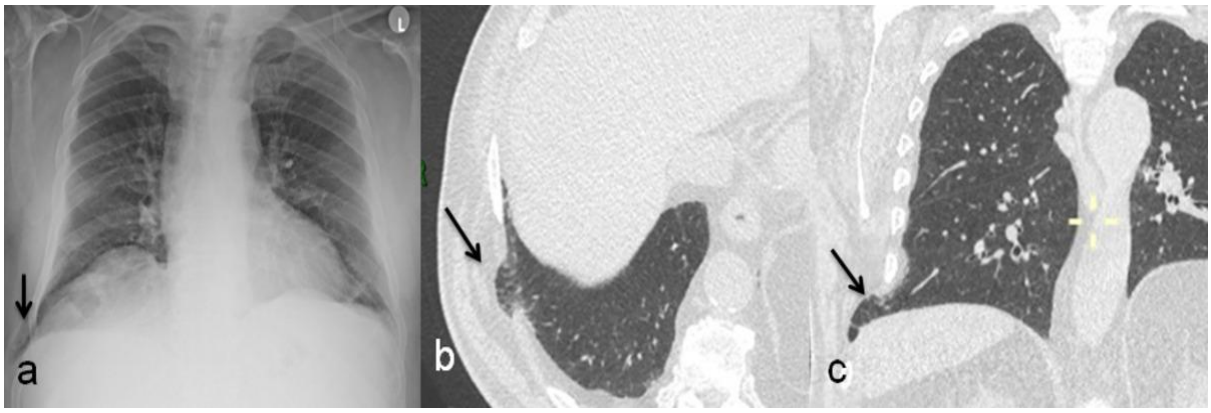

Fig. 12: Frontal chest X-ray (a) in a 75-year-old man shows a focal radiolucency projecting beyond the profile of the lower right ribs (black arrow). CT scan (b) and coronal MPR reconstruction (c) demonstrate that this radiolucency is sustained by a focal herniation of lung parenchyma through the right eight intercostal space, due to weakness of intercostal muscles.
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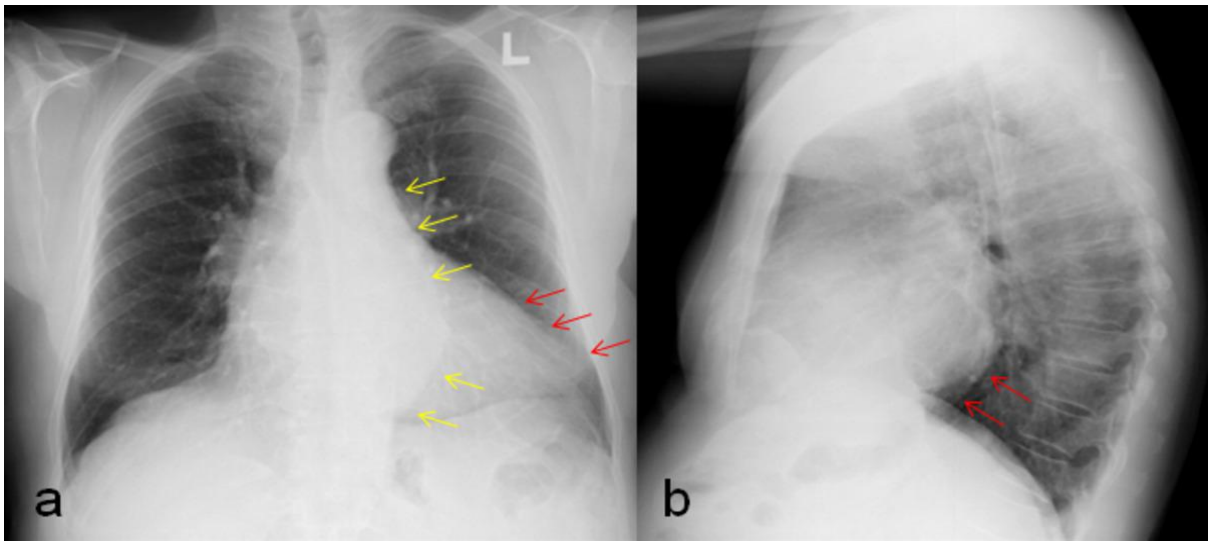

Fig. 13: Frontal (a) and lateral chest X-ray (b) in a 78-year-old man show enlargement of left ventricle (red arrows) and tortuosity of the descending thoracic aorta (yellow arrows). RADIOLOGIA, OSPEDALE SS. ANNUNZIATA - Chieti/IT

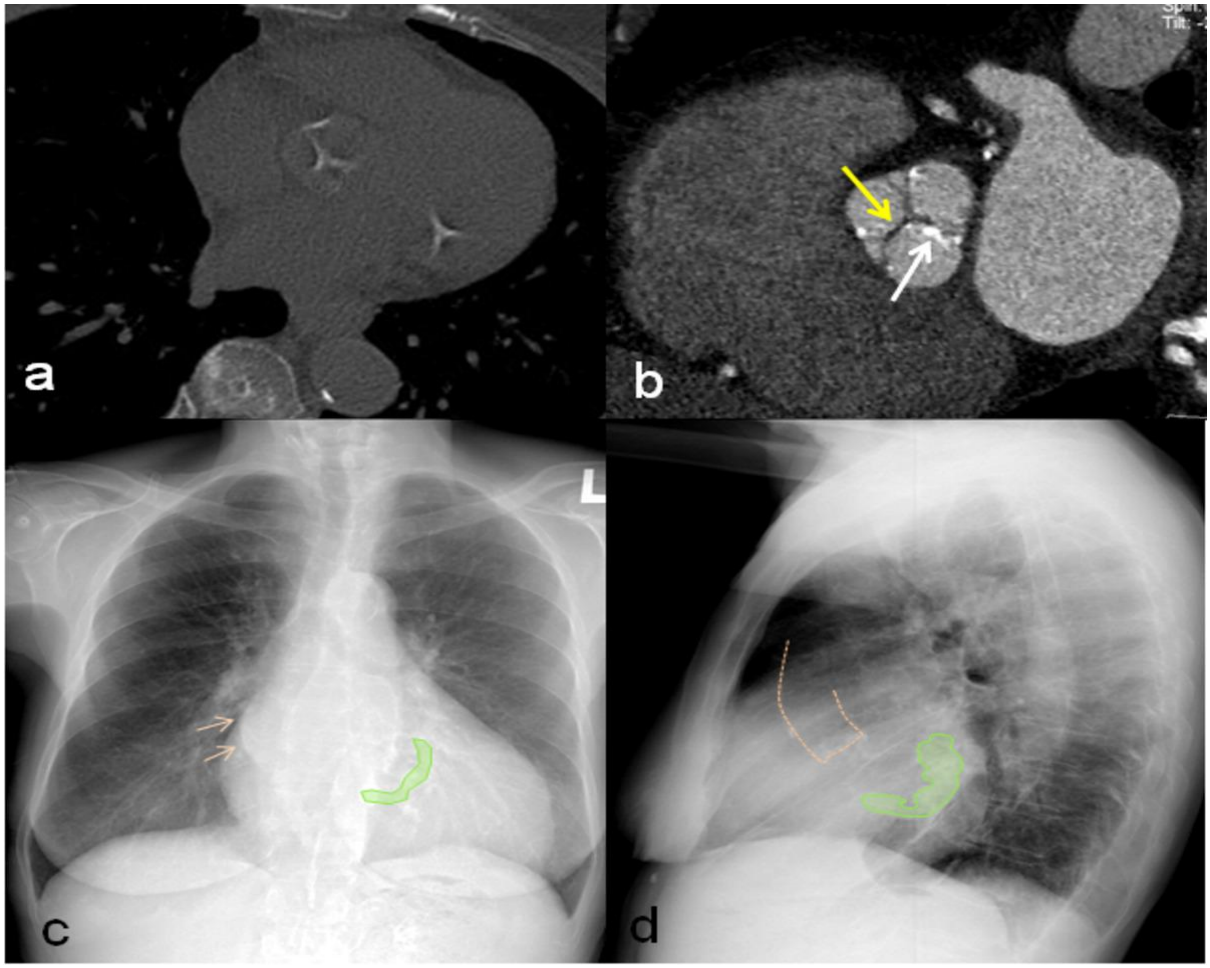

Fig. 14: Chest CT scan (a) without contrast medium shows aortic valve calcification. Cardiac CT scan (b) with reconstruction of an aortic valve during systole, showing thickening (yellow arrow) and calcification (white arrow) of aortic valve leaflets in a 77- year-old patient with no history of cardiovascular disease. Chest X-ray in an 85-year-old woman show calcified mitral annulus (green area) and enlargement and calcification of the ascending aorta (pink arrows in c, pink dashed line in d). RADIOLOGIA, OSPEDALE SS. ANNUNZIATA - Chieti/IT

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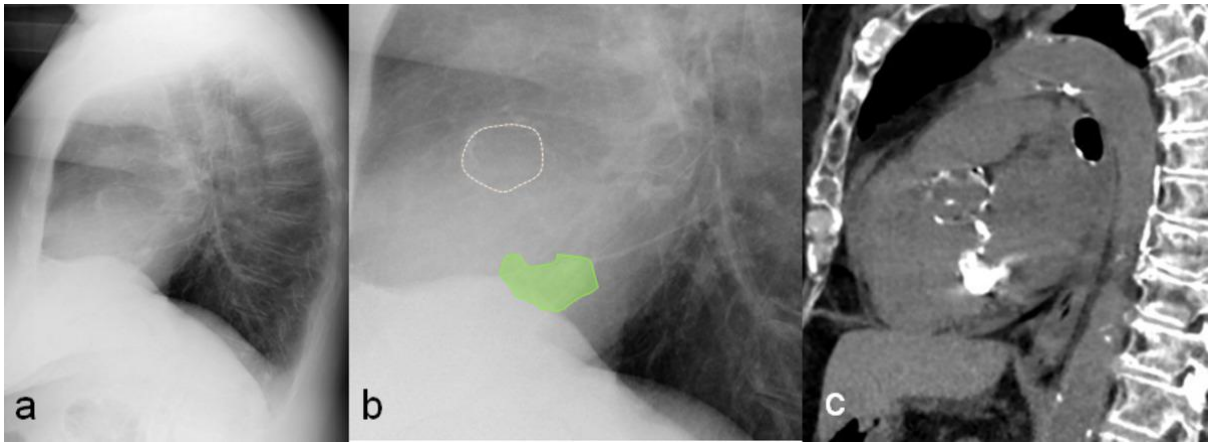

Fig. 15: Lateral chest X-ray (a) and magnification (b) show dense calcification of mitral annulus (green area in b) and calcified aortic valve (pink dashed line in b). MPR sagittal reconstruction confirm the radiographic findings.
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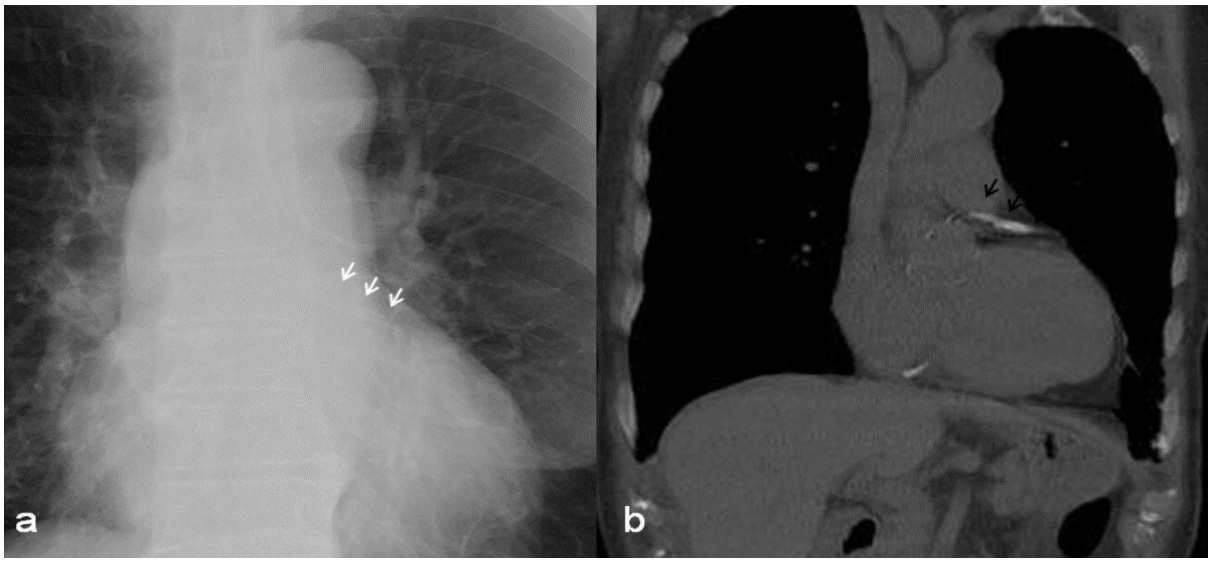

Fig. 16: Magnification of frontal chest x-ray (a) showing a curvilinear calcification (black arrows) below the left main bronchus. Coronal MPR reconstruction reveals that the radiographic finding is consistent with left coronary calcification.
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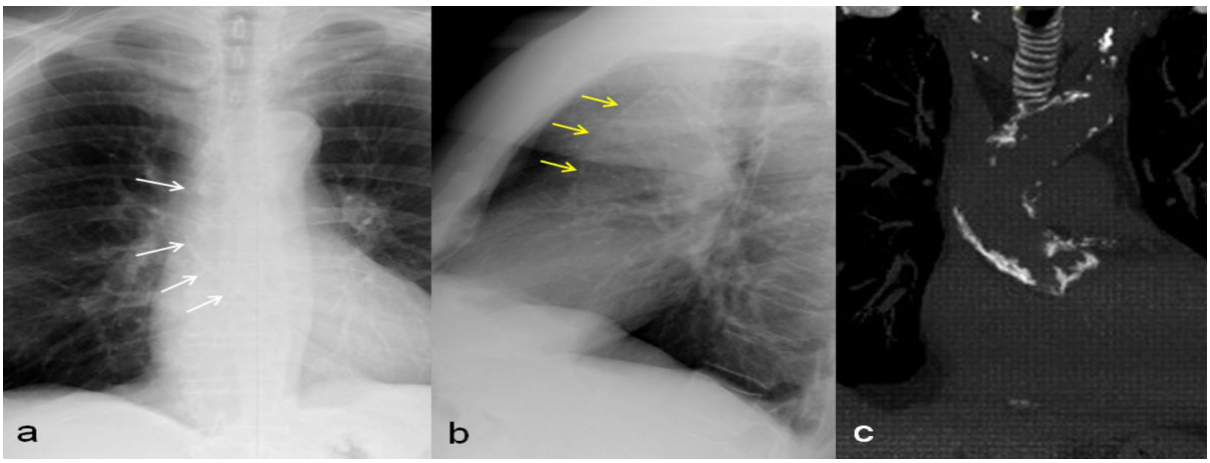

Fig. 17: Frontal (a) and lateral (b) chest x-ray showing parietal thoracic aorta calcification (white arrows in a, yellow arrows in b). Coronal MPR reconstruction confirms calcification of the aorta and aortic valve.
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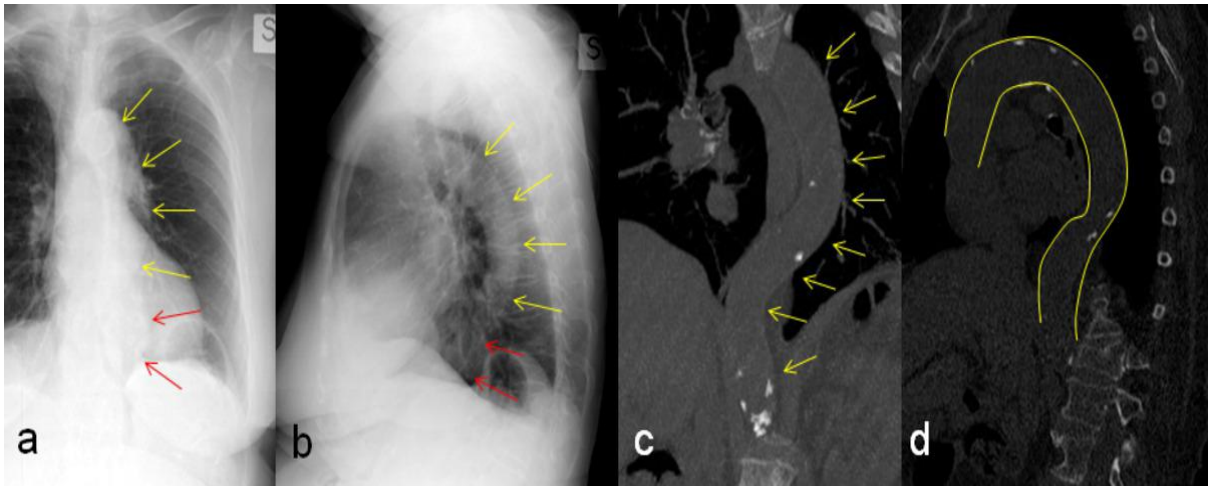

Fig. 18: Chest X-ray (a,b) in a 70-year-old-man showing enlargement, elongation and tortuosity of the thoracic aorta (yellow arrows). Coronal (c) and sagittal MPR reconstructions (d) confirm the same findings. In this patient also coexist a hiatal hernia (red arrows in a and b).
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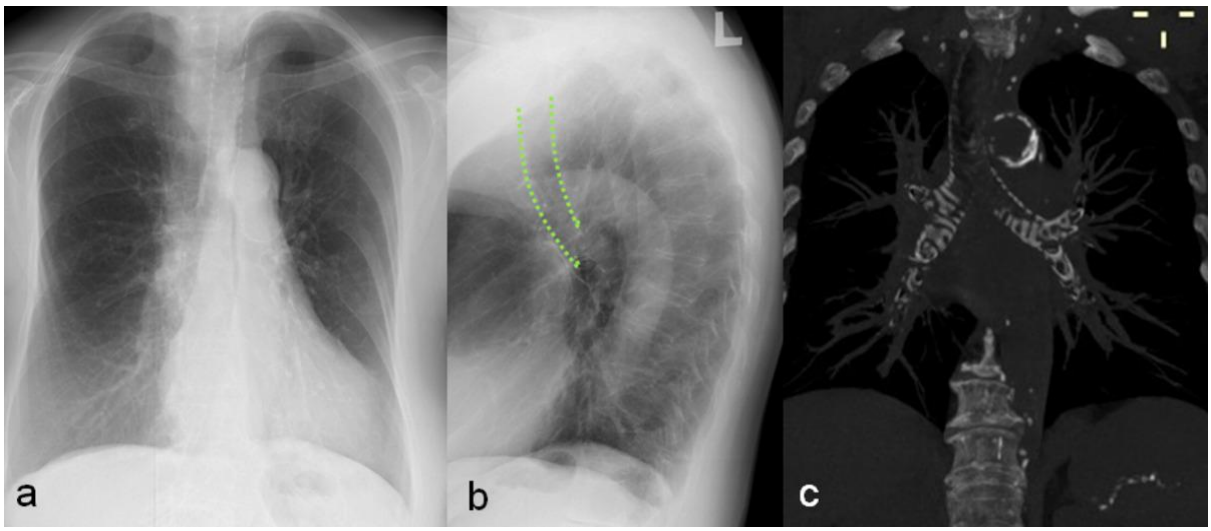

Fig. 19: Chest X-ray (a,b) in a 76-year-old man show diffuse tracheo-bronchial calcification which can be better delineated on MIP reconstructions (c)
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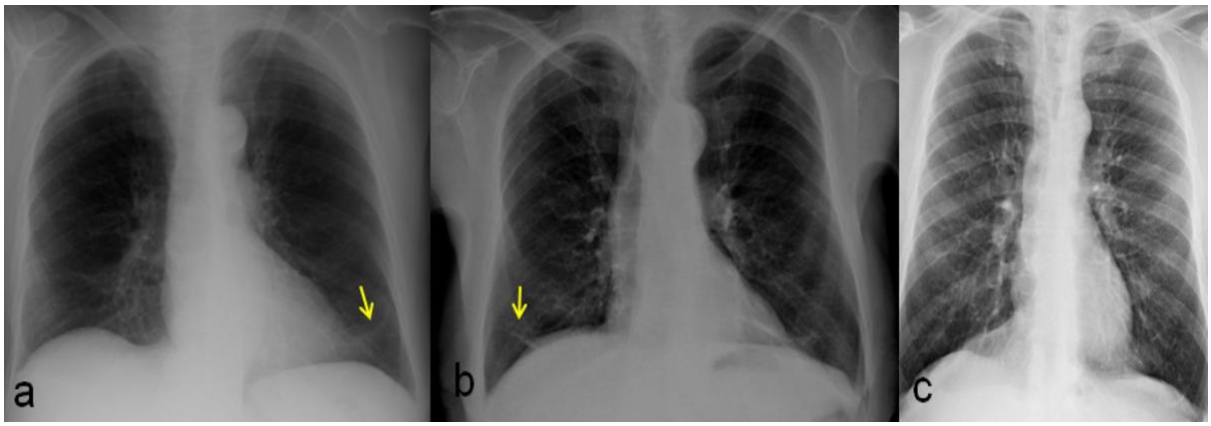

Fig. 20: Chest X-ray (a) in a 92-year-old woman with a pancreatic cancer, showing diffuse hyperluncency, with bronchial wall thickening and diffuse hypoperfusion, due to "elderly lung"; lamellar atelectasia (yellow arrow). Frontal chest X-ray (b) in a 68-year-old man shows diffuse bronchial wall thickening associated with medium-degree obstruction detected with respiratory functional tests. This patients has COPD. Lamellar atelectasia (yellow arrow). Frontal chest X-ray (c) in a 74-year-old man shows diffuse bronchial wall thickening with no respiratory functional tests changes.
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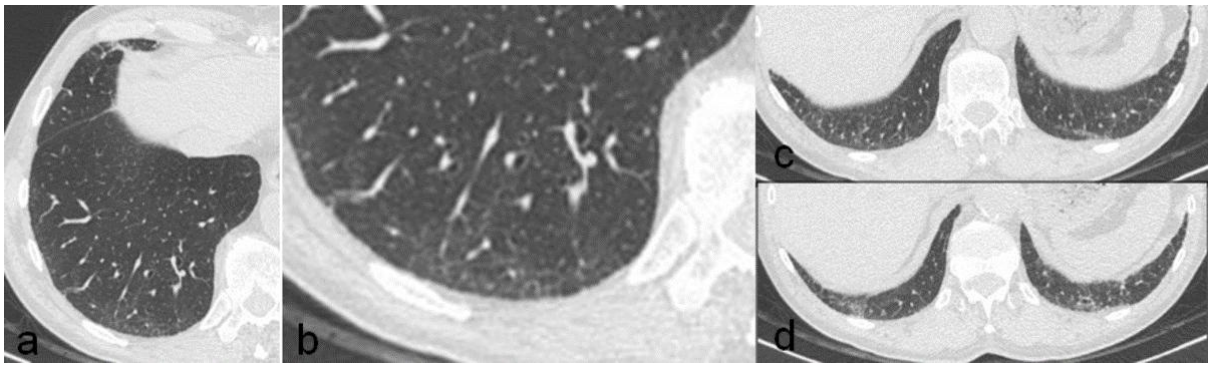

Fig. 21: Chest CT (a,b,c,d) in a 79-year-old man with no respiratory functional tests changes show basal reticular thinckening and distal bronchial wall thickening; these radiological findings were stable for many years. RADIOLOGIA, OSPEDALE SS. ANNUNZIATA - Chieti/IT

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