Chest imaging in the elderly: what radiologists should know about

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Learning objectives

The purposes of our study are:

1) to describe the most frequent chest imaging findings related to aging modifications in order to provide a correct interpretation of the chest images in the elderly;

2) to differentiate between paraphysiological findings related to the aging process and pathological findings, initial onset of a disease.

Background

Societies are getting older, so radiological exams are performed on elderly patients more frequently due to progressive increase in life expectancy. It can be difficult sometimes to differentiate between the ageing processes and the disease itself. Chest imaging in the elderly requires a specific knowledge. Major problems are basically related to the patients themselves because of their frailty, immobility, impossibility for long breath hold, presence of comorbidities (previous surgery, hypertension, renal insufficiency, poor peripheral venous access, etc). In particular chest imaging in the elderly, compared to other anatomical areas, has the problem of motion artifacts due to breath holding which can impair the interpretation of lung parenchyma in chest CT scans. In this scenario chest imaging in these patients should be based on fast technical 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 artifacts due to breath holding. When faster CT scanner are not available other strategies to reduce these motion artifacts include the caudal start of the scan and the use of a higher pitch.

Imaging findings OR Procedure details

Numerous anatomical and paraphysiological changes occur during the aging process involving chest wall, mediastinum structures and lung parenchima; so in the elderly it is often difficult to establish what normality is, or rather, what changes are consistent with the aging process (tab. 1).
Table 1: Changes related to the aging process involving chest wall, mediastinum and lung parenchyma.

**References:** RADIOLOGIA, OSPEDALE SS. ANNUNZIATA - Chieti/IT

1. Chest Wall

   - Dorsal spine
     - **Osteoporosis:** osteoporosis consistent with aging process is not associated with other disturbances and it is called «elderly osteoporosis». In women is more common and more severe. Leads to a vertebral radiolucency reduction (fig. 1).
     - **Spondilosisis, kyphosis and vertebral soma height reduction:** the term spondylosis refers to degenerative changes of the spinal column, including reduced intervertebral space, bone sclerosis adjacent to the intervertebral discs, and marginal vertebral osteophytes. Osteophytosis are more generally pronounced on the right side of the vertebral column because of the projection of the aorta in the left side. Osteophytosis sometimes create nodular images on chest X-ray that can be confused with parenchymal nodules (figg. 2-3).
• **Barrel chest**: is characterized by a pronounced dorsal kyphosis with a more convex sternum with an increase in the antero-posterior diameter of the thorax and atrophy of chest wall muscles. The differential diagnosis should be made primarily with chronic obstructive pulmonary disease (COPD). The diagnosis of COPD should be suspected in presence of other findings such as pulmonary emphysema, bronchial wall thickening and bronchiectasis; the definitive diagnosis requires lung function tests (fig. 4).

- **Ribs**
• **Costochondral calcifications, costovertebral and costosternal osteoarthrosis**: focal costochondral calcifications and costosternal arthrosis, with somatomarginal osteophytes, are the most frequent causes of doubtful pulmonary nodular lesions whose nature is clarified by performing CT exams (figg. 5-7).

- **Diaphragm**
• **Diaphragm bump and diaphragmatic hernia**: diaphragmatic atrophy, weakness and dyskinesia cause elevation and bulging of the hemidiaphragm (figg. 8-9) and sometimes there is the need to differentiate between hemidiaphragm elevation and subpulmonic pleural effusion. In the latter there is an apparent elevation of the hemidiaphragm with a peak more lateral than usually and lung vessels are not visible through the hemidiaphragm (fig.10). These changes are more common on the right side, probably caused by the increased effort of the hemidiaphragm in maintaining the anatomic relationship between the lung and the liver (Figg 8-10).

- **Muscles**
• **Atrophy of the chest wall muscles**: is due to aging-related muscle mass loss, and it is responsible of increase pulmonary transparency. Weakness of intercostal muscles may rarely cause focal herniation of lung parenchyma through the intercostal space (figg. 11-12).

2. **Mediastinum**

- **Heart**
• **Cardiac enlargement**: the enlargement of left ventricle frequently found in elderly patients is due to an increase in myocardial mass and thickness, with a slight hypertrophy of myocytes and an increase of the connective tissue component. These changes should not be confused with hypertensive or dilatative cardiomyopathy, that are independent aging pathological conditions. Although most of these changes have no clinical significance in healthy patients, they can contribute to decompensation in cases of cardiac
overload due to external factors, resulting in a reduction of the functional reserves (fig. 13).

- **Valve calcifications**: valve leaflets thickening is a finding that is considered to be characteristic of normal cardiovascular aging. Thickening of the valvular margins due to deposits of fat, collagen and calcium salts may cause a slight mitral valve insufficiency (present in 90% percent of patients with more than eighty years old) (figg. 14-15).

- **Coronary calcifications**: are difficult to identify in a chest radiograph while they are almost always present on chest-CT images in the elderly. If not performed a coronary-tc or a coronarography is not possible to understand 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 (fig. 16).

- **Aorta**

  - **Parietal calcifications**: aortic atheromatic calcification are frequent but not always related to the gravity of the clinical situation. It is still very important to report the vascular calcification, and in particular those of the aortic arch and the abdominal aorta, as they are independent cardiovascular risk factors (fig. 17).

  - **Enlargement and tortuosity**: repeated mechanical stimuli and elastic connective tissue reduction of the aortic wall are the main causes that lead to aorta lengthening and dilation, with enlargement of the mediastinal contour in chest radiograph frontal projection. Arterial stiffness is now recognized as an independent measure of cardiovascular risk beyond traditional risk factors; stiffening of the proximal aorta has been shown to be strongly related to aging (fig. 18).

- **Trachea/bronchi**

  - **Chondral calcifications**: they do not represent a pathological finding but are very common in the elderly (fig. 19).

3. **Lung Parenchyma**

- **Parenchyma**

  - **Reticular interstitial thickening**
  - **Non-specific bronchial wall thickening**
  - **Lamellar atelectasis**
  - **Elastic component reduction**

- **Vessels**

  - **Reduction of number and caliber**
Finally, in the elderly there is a physiologic aging of the lung parenchyma characterized by macroscopic, microscopic and vascular modifications translating into the "elderly lung". First, macroscopic modifications are due to rib cage deformity, the so called "barrel chest". Second, microscopic modifications are characterized by an increase of the connective tissue, reduction of lung elasticity with subsequent distal airways collapse and increase in residual volume. This mechanism is analogous to that of pulmonary emphysema with three major differences: no signs of alveolar septa destruction, no inflammation, no increase in total pulmonary capacity. Finally, vascular modifications are due to the reduction of number and caliber of the vessels and the capillary bed with reduction of the number of alveoli with optimal gas exchange and consequently a reduction of arterial oxygenation and pulmonary hypoperfusion. Considering these changes the most frequent findings on chest radiography in the elderly are the "barrel chest" with an increased bilateral hyperlucency and homogeneous reduction of vascularization (differential diagnosis with emphysema in which there is a disomogeneous reduction of vascularization), bronchial wall thickening and air bubbles. On chest CT scans these physiological changes are represented by a reticular pattern with thickening of interlobular and intralobular septa, cysts, bronchial dilatation and bronchial wall thickening (fig. 20). In this context the correlation of the extent of fibrotic changes with clinical history, and other pulmonary and extrapulmonary findings is crucial to differentiate these moderate basal fibrosis related to the aging process with those of interstitial lung disease (usual interstitial pneumonia (UIP) and non specific interstitial pneumonia (NSIP)).

It has been recently suggested that smoking-related fibrotic alterations are nothing more than an acceleration of aging processes, mediated by oxidative chronic damage (fig. 21).

Moreover physiological aging of lung parenchyma can be responsible of the development of a minimum degree of pulmonary hypertension that in elderly patients is frequently associated with atherosclerosis and this form a closed circle, each contributing to the other.

It is mandatory to underline that in the chest there are two pumps: the cardiac and the pulmonary that are vital and must be in perfect balance for optimal functioning. 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.
**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.

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

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.
Fig. 5: Chest X-ray (a,b) in an 82-year-old woman showing fairly widespread costocondral calcification. MIP reconstruction (c) confirms the presence of the diffuse condral calcification.

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

**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 hyperelevation of the right hemidiaphragm.
**Fig. 9:** Frontal (a) chest radiograph and coronal MPR reconstruction (b) in an 83-year-old 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).

**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).
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 the hyperlucency of lung parenchyma. CT scan (c) in a 38-year-old woman shows good tropism of the parietal muscles.

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 eighth intercostal space, due to weakness of intercostal muscles.
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).
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).
**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.

**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.
**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.

**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).
**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)

**Fig. 20:** Chest X-ray (a) in a 92-year-old woman with a pancreatic cancer, showing diffuse hyperlucency, 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 patient 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.
**Fig. 21**: Chest CT (a,b,c,d) in a 79-year-old man with no respiratory functional tests changes show basal reticular thickening and distal bronchial wall thickening; these radiological findings were stable for many years.
Conclusion

Radiologists have to be aware of all the numerous changes occurring in the aging process involving the chest wall, the mediastinum and the lung parenchyma and they must have a rigorous method of evaluation of all these sub-components in order to identify the signs of an initial onset of a disease, a great advantage to timely treatment.

Therefore the chest imaging findings should be always associated with the clinical context and previous examinations; whenever necessary a follow-up exam must be requested.

References


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**Personal Information**