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Conventional Roentgen Diagnosis of Mediastinal Lymphadenopathy Review Article (Part two)

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Summary

Although CT has significantly improved the imaging of space occupying mediastinal processes, it cannot be the first diagnostic step for reasons of cost, radiation exposure and capacity. Therefore, the conventional chest examination with biplane films, film tomography and esophagogram continues to be the basic roentgen procedure. The basis of the conventional studies is the analysis of the pleuro-mediastinal borders. This paper describes the roentgen-morphological aspects of enlarged lymph nodes in the mediastinal compartments as far as they can be detected with conventional studies. The differential diagnoses are discussed and recognition of early and discrete lesions is particularly emphasized.

The first part of this review deals with the significance of the conventional roentgen examination for detecting mediastinal lymphadenopathy (1). The anatomy of the mediastinal compartments is described with special reference to the distribution of lymph nodes (2.1). The normal and pathologic roentgen anatomy of the paratracheal region is discussed and illustrated (2.2). This second part is to deal with lymphadenopathy in the aortic pulmonic window (2.3), subcarinal lymphadenopathy (2.4) and lymphadenopathy in the posterior mediastinum (2.5)

2.3 Lymphadenopathy in the aortic-pulmonic window

2.3.1 Normal anatomy (Fig. 1)

The aortic-pulmonic window is formed cranially by the convexity of the aortic arch, caudally by the surface of the left pulmonary artery or the pulmonary trunc, medio-ventrally by the trachea, and medio-dorsally by the esophagus. Laterally the window is open and

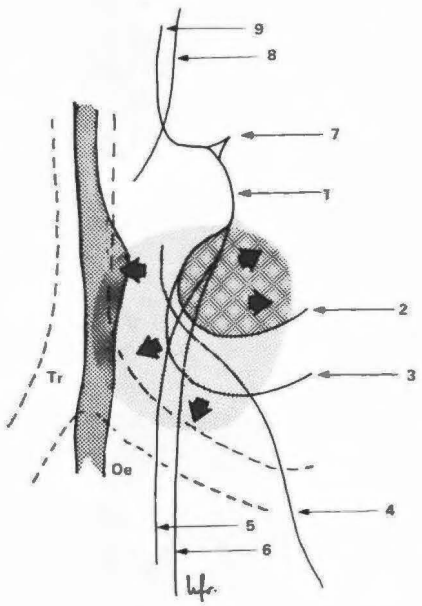


Fig. 1 Enlarged lymph nodes (dotted) in the aortic-pulmonic window tend to expand into all directions (→), and can make impressions on the esophagus (oe), the trachea (tr) and the left main stem bronchus. They become visible on the plain film only if they displace the pleura of the left lung (darkly dotted). 1. aortic arch, 2. aortic-pulmonic line, 3. aortic-venous line, 4. paracardio-vascular line, 5. pre-aortic line, 6. para-aortic line, 7. aortic "nipple", 8., 9. left subclavian vein and artery

contains a pleural pouch of variable size which is filled by tissue of the left lung (2, 3), (Fig. 2). Medially, in the nearest vicinity of this pouch, there is a number of nervous structures (left vagal nerve, left recurrent nerve, left peri-

Fig. 2 Deep pleural pouch from the left lung extending into the aortic-pulmonic window in a patient with emphysema. Normally, the pouch is more shallow or may be even absent (see Figs. 1 and 3a)

cardiocophrenic nerve, periaortic and peripulmonic sympathetic plexus, including *Wrisberg's* ganglion), the ligamentum Botalli, left bronchial arteries and, occasionally, an accessory left superior intercostal vein. The arteries are surrounded by small lymph nodes, variable in size and number, to which the one or two "ductus nodes" belong. These nodes, as well as the nodes of the left main chain and the ligamentum Botalli may be calcified and detectable on the conventional film.

According to the great number of vascular structures in this region, a variety of pleural folds may occur which cast variable corresponding curvilinear lines (aortic-pulmonic line, pre-aortic line, aorto-venous line (3 - 5), (Fig. 1).

2.3.2 Pathologic anatomy in lymph node enlargement

Enlargement of the "ductus node(s)" or nodes belonging to the left main chain can be seen in malignant lymphomas, lymph node metastases, sarcoidosis or infectious lung disease and is the main reason for a space occupying process in the aortic-pulmonic window.

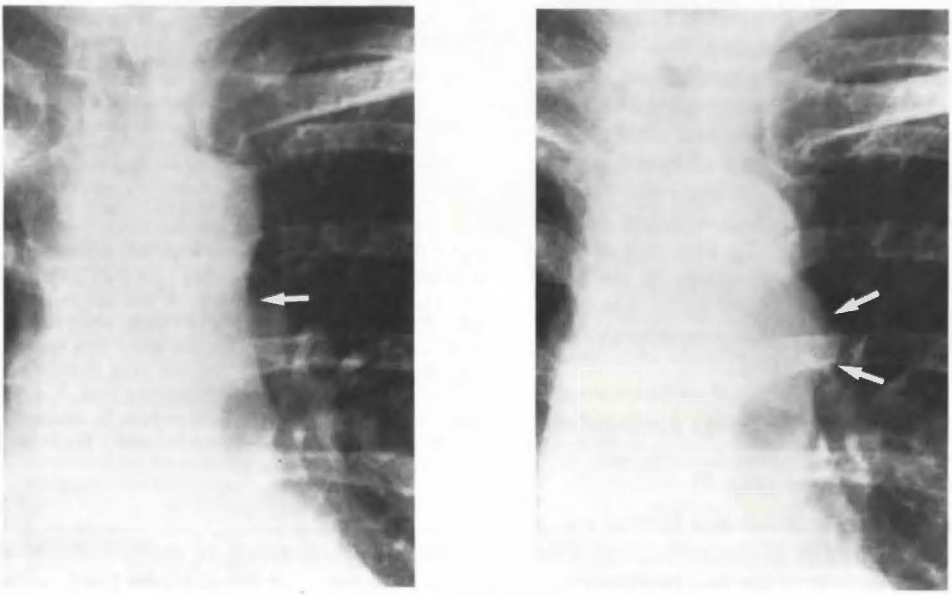


Fig. 3 Metastatic lymph node enlargement in the aortic-pulmonic window in a patient with malignant melanoma (b). The film taken 6 months before was normal (a)

As the window is approximately twice as large in the sagittal diameter than in the frontal diameter, space occupying processes can nearly fill the window by extension in the anterio-posterior direction, before they become visible on the sagittal film. A space occupying process may expand towards the esophagus as well, producing an impression from the left below the aortic arch or even displacing it (Fig. 1). Therefore, an esophagogram is always required when a mass in the aortic-pulmonic window is suspected. For precise analysis however, additional film tomograms are needed with the esophagus stained with barium. Because of the great individual variability of this region, follow-up studies are of greatest value (Fig. 3).

Lymphadenopathy of the aortic-pulmonic window is frequently seen in sarcoidosis and malignant melanoma. This region must be scrutinized in all patients with bronchiogenic carcinoma because roentgenologic evidence of metastatic lymph node enlargement in the aortic-pulmonic region may mean local inoperability. This roentgen sign is important as this region is not susceptible to routine mediastinoscopy.

2.3.3 Differential diagnosis

Tumors originating from the sympathetic (neuroblastoma) or the peripheric nerves (neurinoma) of the aortic-pulmonic region cannot be differentiated from lymph node enlargement with conventional methods. A patent ductus arteriosus may also obliterate the aortic-pulmonic window; in neonates this is known as the "ductus bump" (6).

The so-called "aortic-nipple" (Fig. 4) must not be confused with lymphadenopathy. The position of this rounded or triangularly shaped protuberance varies in relation to the aortic knob from superomedial to inferomedial (12, 24), measuring up to 10 mms. It can be detected in approximately 4% (1.7–9.5%) in all age groups (7, 8, 12, 24) and is formed by the left superior intercostal vein which drains the left second, third and fourth intercostal veins and connects the accessory hemiazygos vein with the innominate vein or the left jugular vein, respectively (8–11, 24). In German literature (12) the left superior intercostal vein is also referred to as the accessory hemiazygos vein.

Fig. 4 The aortic "nipple" must not be confused with mediastinal lymphadenopathy. This protuberance from the aortic arch is caused by the left superior intercostal vein which crosses over the aortic arch

Distension of the left superior intercostal vein usually is a result of an increase in blood flow or venous pressure (congestive heart failure, increased portal venous pressure with collateral blood flow, obstruction or a congenital anomality of the caval veins, anomalous venous drainage), (8–11, 24).

2.4 Subcarinal lymphadenopathy

2.4.1 Normal anatomy

Normally, the space just below the tracheobronchial angle contains only some smaller lymph nodes, predominantly under the right main bronchus and the right intermediate bronchus, connective tissue and various amounts of fat. The right lung posteriorly bulges into the mediastinum, forming the infraazygeal or interazygo-esophageal recess which lies dorsal to the tracheal bifurcation. The most cranial part of this pleural sac may extend into the more ventrally located subcarinal area and behind the bifurcation. This part of the pleural sac is also referred to as subcarinal and retrobronchial

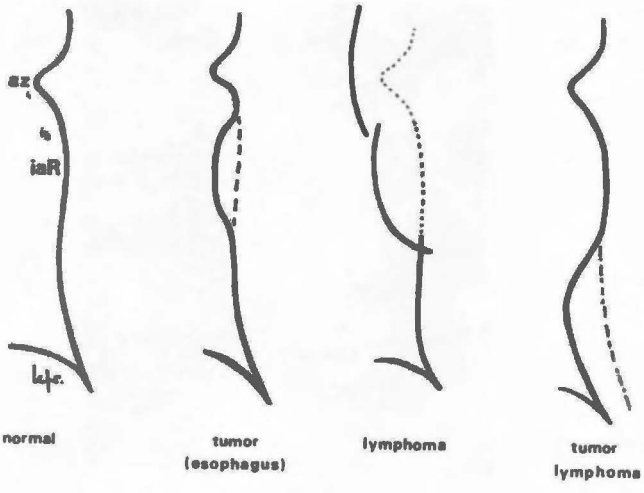


Fig. 5 Pathologic course of the right para-esophageal line below the azygos arch (az) is predominantly due to esophageal tumors or enlarged lymph nodes in the posterior mediastinum in close vicinity to the esophagus. iaR: infra-azygeal recess of the right lung

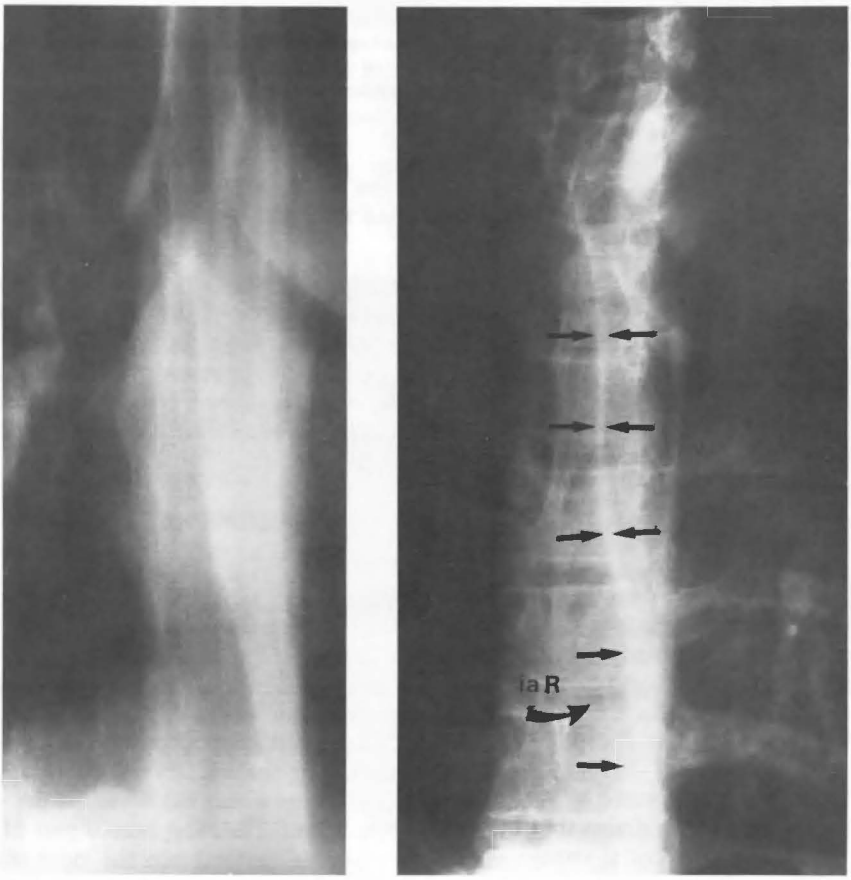


Fig. 6 Normal right para-esophageal line (a) and normal posterior junction line (b) in the infra-azygos area. iaR: infra-azygeal recess of the right lung

recess (Figs. 5, 6) and can be found above all in patients with emphysema (13).

The subcarinal pleural recess is made up by the following anatomical structures: superiorly the azygos arch, posteriorly the prevertebral soft tissues, medially the right wall of the esophagus (which can be seen as the right para-esophageal or azygo-esophageal line) and anteriorly the posterior walls of the bifurcation and the horizontal part of the right pulmonary artery which often protrudes like a rim. The inferior border of the subcarinal recess is normally formed by the right upper pulmonary veins, which enter the pericardial sac in this region. Laterally, the subcarinal recess is in contact with the medial wall of the left intermediate and main bronchus, which normally is only poorly contrasted against the translucent lung tissue in the subcarinal recess. The anatomy of this region has been recently described by *Remy* et al. (13).

The right para-esophageal line can be seen on the sagittal chest film in approximately one half of all young people and is less frequent in persons aged over 40 years (18.5 %, (7)), (Fig. 6a). A posterior junction line below the azygos arch is a rare finding and predominantly seen in patients with emphysema (7), (Fig. 6b).

2.4.2 Pathologic anatomy in lymphomas

Subcarinal lymph node enlargement may produce a variety of roentgen symptoms (13). Enlarged nodes on the medial surface of the right main or intermediate bronchus displace and narrow the subcarinal recess. This leads to a better recognition of the right bronchus in this portion as the soft tissues contrasts with the air within the tracheobronchial tree.

More enlarged lymph nodes expand against the right wall of the esophagus and obliterate the most cranial portion of the right para-esophageal line. This is never an early sign but always indicative of considerable lymph node enlargement. A normal right para-esophageal line therefore does not exclude more discrete enlargement of nodes behind the pulmonary artery or under the right main or intermediate bronchus.

Massive subcarinal lymph node enlargement can also be detected in the lateral projection as a soft tissue mass contrasting sharply against the displaced subcarinal or interazygo-esophageal recess. A widening of the bifurcation angle or a compression of the main bronchi or of the pulmonary arteries are signs of far progressed lymphadenopathy in this region and the adjacent parts of the mediastinum and the hila (Fig. 8–9).

2.4.3 Differential diagnosis

An obliteration of the azygo-esophageal recess is not specific for subcarinal lymphadenopathy; it may also be due to a benign or malignant process originating from the esophagus (14) (Fig. 7). A more segmental obliteration of the mediastinal borders can be seen in a prominent pulmonary venous confluence as well and is very common if the left atrium is significantly enlarged in mitral valvular disease (15). The dilated right pulmonary artery, too, may deform the borders of the subcarinal recess (13).

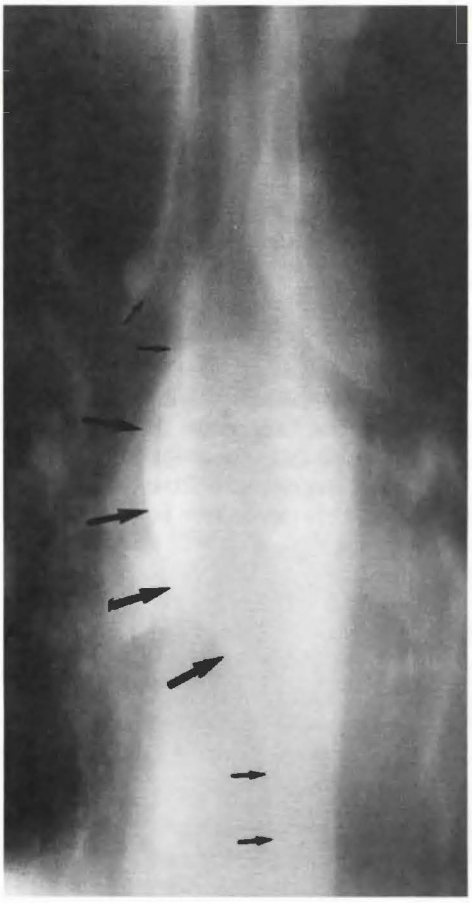
2.5 Lymphadenopathy in the posterior mediastinum

2.5.1 Normal anatomy

The following lines originating from structures in the posterior mediastinum can be demonstrated on the sagittal chest film in normal adults: right para-esophageal line (45 %), right para-spinal line (23 %) and left para-spinal line (8 %), (7). The visualization of these lines very much depends on the exposure dates (choice of screen, film, grid, kilovoltage). The para-spinal lines parallel the spine at a distance of 1–5 mm on the right and 3–8 mm on the left (7, 16–18). The right para-esophageal line runs slightly curved over the spine and in its most inferior portion turns somewhat to the left (14). The para-aortic line is formed by the descending aorta and can be demonstrated in nearly all normal cases within the heart shadow, paralleling the left para-spinal line.

2.5.2 Pathologic anatomy in lymphadenopathy

The most common cause of lymphadenopathy in the posterior mediastinum is an infiltration *per continuitatem* through the anatomic



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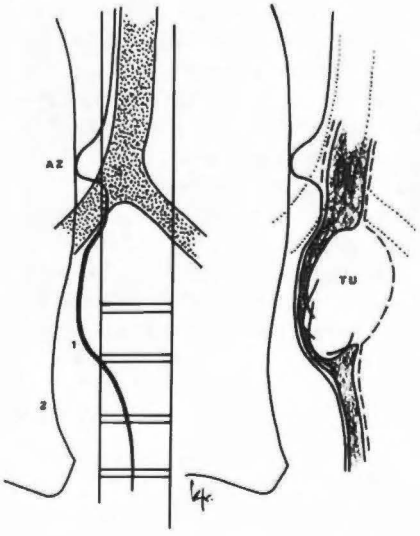

7c

Fig. 7 Benign leiomyoma of the middle portion of the esophagus. a) Bulging of the upper part of the right para-esophageal line in the infra-azygos area; the lower part is still normal. b) The esophagogram shows a lobulated excentric mass within the wall of the esophagus with intact mucosa. c) Scheme: az = azygos arch, 1. right para-esophageal line, 2. right heart border

Fig. 8 Lymph node metastasis from breast cancer. The lateral tomogram with barium-stained esophagus shows metastatic involvement of sub- and retrocarinary (bifurcational) nodes in the mediastinum

foramens of the diaphragm arising from enlarged para-aortic retroperitoneal nodes. Bilateral involvement of these posterior mediastinal nodes including the retrocrural nodes will result in a triangular shaped, sharply defined mass with the apex upward and the lateral contours melting with the shadows of the diaphragm. This is also known as *iceberg sign* (19). Unilateral manifestation is also possible. Retrocrural nodes can be detected by ultrasound only in gross enlargement and if the overlying stomach is not filled with gas; CT is much more reliable.

Primary involvement of the nodes in the posterior mediastinum, however, is a rare finding. The roentgen signs depend on the very localization of the nodes and many of them result in a displacement or an obliteration of the para-spinal lines, the para-aortic line and/or the right para-esophageal line.

Displacement of the para-spinal lines will occur if the lymph nodes expand along the lateral surfaces of the spine and displace the pleura (Fig. 10). It is not exspected if the nodes are enlarged only in the para-aortic and pre-spinal region. Extension along the esophagus will result in displacement and atypical configuration of the para-esophageal line (Fig. 11). If the

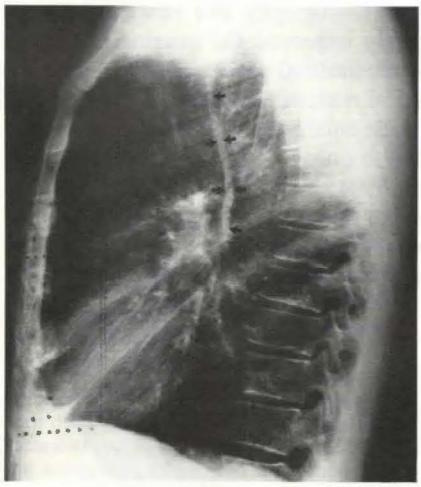

Fig. 9 Central bronchiogenic carcinoma of the right lung. On the sagittal view (not demonstrated) only moderate enlargement of the right hilum. a) Lateral view: thickening of the posterior tracheal band, indicating a pathologic process in the (right) hilum, the retrocarinal or the peri-esophageal area. b) CT scans show the tumor masses in the right hilum and metastases (M) to the retrocarinal and para-esophageal nodes

Fig. 10a

Fig. 10b

whole posterior mediastinum is filled with lymphatic masses, none of those lines will be discernible within the soft tissue mass.

2.5.3 Differential diagnosis

Among the solid masses in the posterior mediastinum the neurogenic tumors form the greatest group. In the vicinity of the diaphragm, hiatal hernia must be considered, dissection or kinking of the descending aorta, benign and malignant tumors of the esophagus, spinal tumors, extramedullary hematopoiesis (20), paraspinal abscesses in spondylitis or spondylodiscitis, post-traumatic hemorrhage (21) and dilated veins (azygos, hemiazygos) in agenesia of the inferior vena cava with azygos continuation or in pathologic collateral circulation may occur (15, 23). Deviation of both para-aortic (22) and left para-spinal line (18) may be associated with an enlarged left atrium in mitral valvular disease. A careful analysis of the pleuro-mediastinal lines in the posterior mediastinum can help to narrow the spectrum of differential diagnoses considerably (23) and has a strong influence on the following diagnostic procedures. In the roentgen evaluation of posterior mediastinal masses the esophagogram is mandatory.

Discussion

Computed tomography as a new modality has significantly improved the imaging of space occupying mediastinal processes. While *ultrasound* for physical reasons can detect mediastinal lymph node enlargement in the thoraco-abdominal region only inconstantly, *computed tomography* is able to image the whole mediastinum. For reasons of costs, capacity and radiation exposure, however, CT cannot be the first diagnostic step: conventional studies of the chest continue to be the basic examinations.

Fig. 10 Hodgkin's disease involving the nodes of the posterior mediastinum and infiltrating the 10th thoracic vertebral body. a) Sagittal view of the thoracic spine: gross displacement of the left para-spinal and para-aortic line and lesser displacement of the right para-spinal line. Sclerosis of the 10th vertebral body. b) Infiltration of the vertebra and surrounding soft tissue mass confirmed by CT

Fig. 11a

Fig. 11b

Fig. 11 Teratocarcinoma with metastases to the lymph nodes in the posterior mediastinum. a) Gross bulging of the right para-esophageal line with only discrete displacement of the right para-spinal line, indicating a space occupying process lying before the spine and extending along the esophagus. b) Enlargement of nodes in the posterior mediastinum is demonstrated with CT; the lymphoma extends ventral to the spine. c) Scheme

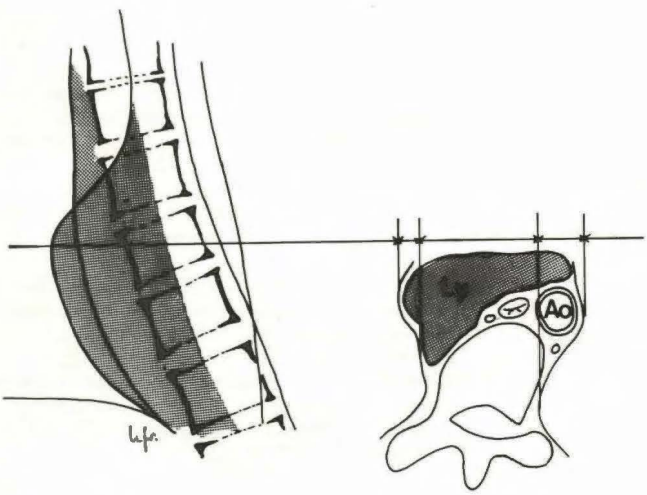

Fig. 11c

The conventional chest examination starts with biplane chest films and a heavily exposed sagittal film. It is supplemented by film tomography in frontal and sagittal planes. If possible, tomographic sections should be obtained with the patient in upright position, using a high kV-technique (100 kVp) and a wide focus-film-distance. With the patient in recumbent position, tomography will often give lower contrast of the mediastinal borders as the mediastinum flattens dorsally due to the gravitational force, thus changing the pleuromediastinal interfaces which no longer parallel the x-ray beam. Interfaces that do not parallel the x-ray beam, however, do not produce clear lines. As the analysis of the pleuro-mediastinal lines and stripes is the basis of the conventional studies, tomography with the patient standing upright should generally give the best results.

Barium studies of the esophagus with fluoroscopy and spot films are requested in any suspected or proved space occupying process in the posterior or middle mediastinum to detect more discrete impressions on the esophagus by lymphomas in the aortic-pulmonic window and in the retro-carinal region.

Conventional roentgen studies of the chest should be performed in malignant lymphomas and neoplastic disease

1) as a screening procedure if mediastinal lymph node involvement is suspected or must be excluded
2) as follow-up study under therapy to evaluate and document the effectiveness of treatment
3) as follow-up study after therapy to control the remission and to early detect recurrencies.

Specially the latter task requires an intimate knowledge of the normal anatomy and its variations and of typical therapeutically induced abnormalities. Only by this characteristic early changes can be detected and sufficiently treated.

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