Anatomical Pathways of Lymphatic Flow between Lung and Mediastinum

Ann. Ital. Chir., LXX, 6, 1999

H. NEEF

Section of Thoracic Surgery
Martin Luther University Halle Wittenberg, Germany

Abstract

The knowledge of anatomical lymphatic drainage pathways between lung and mediastinum and metastatic spread patterns of lung cancer forms the basis for the modern TNM classification for the staging of lung cancer. Clinical and anatomical studies divided pulmonary nodes into intrapulmonary and bronchopulmonary, the latter distinguished into lobar and hilar nodes. Mediastinal nodes are grouped into anterior prevascular, tracheobronchial, paratracheal and posterior nodes. The different pathways of lymphatic drainage of the lungs to the mediastinal lymph nodes are presented with the consequent surgical implications.
Key words: Lung cancer, lymphatic drainage, TNM classification, mediastinal nodes, lymph node map.

Riassunto

La perfetta conoscenza delle strutture linfatiche poste tra polmone e mediastino e delle vie di diffusione metastatica linfonodale rappresenta la base razionale del moderno sistema di classificazione TNM per la stadiazione del carcinoma polmonare. Studi clinici ed anatomici hanno consentito di dividere le stazioni linfonodali polmonari nei sottogruppi intrapolmonare e broncopolmonare, quest'ultimo a sua volta suddiviso in linfonodi lobari ed ilari. I linfonodi mediastinici sono stati differenziati in anteriori prevascolari, tracheobronchiali, paratracheali e mediastinici posteriori. Le differenti vie di flusso linfatico tra polmone e mediastino vengono accuratamente descritte con le conseguenti implicazioni sul piano chirurgico terapeutico.
Parole chiave: Carcinoma polmonare, drenaggio linfatico, classificazione TNM, linfonodi mediastici, mappa dei linfonodi.

Most descriptions of pulmonary lymphatics are concerned to anatomical principles. However the surgeon operating on lung cancer must know how and where a given region can drain. Clinical observations tend to favour this possibility. Very early Systematic excision of mediastinal lymphatic chains has shown the presence of tumoral mediastinal lymph nodes without any intrapulmonary diseased lymph nodes.

Informations for a modern picture of lymphatic pathways between lung and mediastinum have been worked out by anatomists, pathologists, thoracic surgeons, radiologists and others.

The history of research to define the lymphatic pathways between lung and mediastinum is given in Tab. I. It shows the markstones: crossing over to the contralateral side (Ronvière 1932), lymphatic sump (Borrie 1952), overlapping drainage from segments and lobes (Hoffinann 1952) and a list of the findings around lung cancer. Different methods were used (Tab. II). For example Hoffinann (1959) used the Gerota technique, namely subpleural injection of Terpentin Äther and Prussian Blue. The clinical or intravitam studies were mainly concerned to the spread of lymphatic metastasis of bronchogenic cancer. In anatomical studies the material were often newborn and infant lungs; seldom adult cadaver lungs. Most progress came from examinations of operation specimens.

The lung has an extensive network of lymphatic vessels which is situated in the loose connective tissue beneath the visceral pleura and in the interlobular septa and in the peribronchial-vascular sheats. This superficial and deep intrapulmonary system has connections crossing the interlobar septa. Flow is directed toward the hilar area in a centripetal direction (Tab. III).

The subpleural network drains to the hilar area, but direct connections to the mediastinal nodes have been recorded by Ronvière (1932), Borrie (1952, 1965), Riquet (1989). The channels in the lobular septa have multiple connections with the channels in the bronchovascular sheats.

Pulmonary lymph nodes

(Tab IV) are divided into intrapulmonary and bronchopulmonary nodes. The latter are subdivided into the

Tab. Ia – HISTORY OF RESEARCH IN LYMPHATIC DRAINAGE PATTERN (acc. to Greschuchna and Maassen 1973)

1787	*Mascagni*	Lymph channels from lower part of left lung → Right paratracheal LN
1912	Ghon	Confirmation
1962	Nohl	
1908	*Most*	Para- and subaortic LN (Most Nodes)
1909	Bartel	LN-Scheme
1923	Corning	Drainage lower and upper parts different
1924	Brauns	LN bronchopulmonales
1926	Engel	LN Ductus arteriosus, Left lung → Right LN tracheobronchiales
	Franke	LN lig. pulmonale
1928	Steinert	Right → Left paratracheal LN
1932	*Rouviére*	*Cross over Left lower lobe → right Parts of right upper lobe → left*
1948	Walther	Truncus mediastinalis ant. et post.
1951	Weinberg	Confirmation Rouviére
1952	Borrie	Lymphatic sump
1953	*Hajek*	*Summary, State of today*
1956	Link	Mediastinal lymphflow cannot be calculated
1956	Thomas	There is no scheme for metastasis
1957	Tobin	
1958	*Kubik*	*Segmental drainage -> special LN*
1958	Cordier	Segmental drainage
1959	Hoffmann	No anatomical "individual" pattern lobe – interlobar pathways
1985	Glazer	CT Number and size of normal
1988	Kiyono	Autopsy mediastinal nodes
1981/1990	Hata	Lymphoszintigraphy

Tab. Ib – HISTORY OF RESEARCH IN LYMPHATIC DRAINAGE PATTERN BRONCHOGENIC CANCER (acc. to Greschuchna and Maassen 1973)

1931	Takino	left upper lobe → right supraclavicular
1961	Sentenac	no rule for lymphogenic metastasis
1956	Nohl - Oser	Metastasis scheme
1962		
1964	Klingenberg	Significance of
1962	Nohl	lymphatic drainage
1969	Munka	patterns, cross over
1959	Hoffmann	Drainage of one segment not individual, but to neighbouring regions
1969	Nohl - Oser	Contralateral
1969	Sarin	metastasis
1967	Maassen	673 (!) patients with mediastinoscopy
1962	Maassen	Mediastinoscopy
1973	Greschuchna Maassen (Monography)	19% contralateral or bilateral metastasis

Tab. II –METHODS FOR EVALUATION OF LYMPHATIC PATHWAYS

Anatomical Studies
- Injection techniques (Hoffmann)
- Normal cadavers (Kiyono)
- Resection specimens (BC)

Clinical or Intravitam-Studies
- Mediastinoscopy (Nohl-Oser, Greschuchna + Maassen)
- Op-Situs (Nohi-Oser)
- Computertomography (Glazer)
- Lymphoszintigraphy (Hata)
- Transoesophageal Ultrasouncl (Kondo)

Tab. III – LYMPHATIC DRAINAGE OF THE LUNG (SHIELDS 1994) LYMPHATIC CHANNELS

Superficial:	Subpleural piexus → interlobular septa → hilus also direct connections to the mediastinum!
Deep:	Sheats of airways and blood vessels → hilus Lobular septa along pulmonary veins

Connections between lobular septa and bronchovascular sheats

Tab. IV – PULMONARY LYMPH NODES (Shields 1994)

Intrapulmonary
Bronchopulmonary
- Hilar
- Lobar
- Interlobar (Borrie 1952, Nohl-Oser 1972) superior n, inferior n.
- Right Lymphatic sump
- Left Lymphatic sump
- Other Interlobar n. right lung upper, middle, lower n. (Borrie 1965)
- Other Interlobar n. left lung upper, lower n. (Borrie 1965)

Note:
Right
Subcarinal nodes belong to the mediastinal compartment.
Nodes medial to the right main bronchus when located away from the tracheal carina are hilar nodes.

Left
Hilar n. lying anteriorly left main stem bronchus contiguous with subaortic nodes belong to the mediastinal compartment.
Hilar n. at medial surface of left main stem bronchus → subcarinal

lobar and hilar nodes. The hilar nodes are situated along the lower parts of the mainbronchi or pulmonary artery and veins lying within the visceral pleural reflections. Hilar nodes are contiguous with the lobar nodes distally and mediastinal nodes proximally.
Lymph nodes medial to the right main bronchus are considered as hilar nodes when located away from the

carina; if they are adjacent to this structure they are called subcarinal lymph nodes and thus belong to the lymph nodes of the mediastinal compartment. On the left side the anatomic separation between the hilar and the mediastinal lymph nodes is at a plane connecting the lateral surfaces of the ascending aorta and the descending aorta. The left hilar nodes are located to the left main bronchus and main pulmonary artery. The latter are contiguous with the subaortic nodes of the mediastinum including the Bartello-node (Lig. arteriosum).

Lobar nodes:

In the right lung the most common location is between upper and middle lobe bronchus. (right bronchial sump Borrie 1952, superior interlobar node Ronvière 1932) and the region just below the middle lobe bronchus (inferior interlobar lymph node Ronvière 1932).
At left side the most common location is at the angle of left upper and lower lobe bronchus (left lymphatic sump Borrie 1952 or left interlobar node Ronvière 1932).
Right lymphatic sump is shown in this picture from Nohl-Oser (1956, 1972, 1989), the left in the next picture (Fig. 1, 2).
Lymphatic drainage of the lobes is primarily to the bronchopulmonary nodes, although direct drainage to the mediastinal nodes was described by Ronvière (1932), Borrie (1952) and Riquet (1989).
The right upper lobe lymphatic drainage (Borrie 1956), is commonly to one of the superior interlobar lymph nodes (right sump) on the lateral aspect of the bronchus intermedius, to the nodes above and medial of the right upper lobe bronchus. Further drainage goes to the azygos or subcarinal lymph nodes. Drainage has not been described to lymph nodes below the level of the right lymphatic sump.
The middle lobe drains to lymph nodes of the superior sump region, or to the inferior sump node.
Drainage from the right lower lobe is to the inferior interlobar node and to the superior sump nodes, primarily those lying on the medial surface of the bronchus intermedius.
Drainage of the left upper lobe from all segments occurs to the left sump nodes. Nodes about the upper lobe bronchus and the left main stem bronchus also receive drainage from this lobe. Lymphatic drainage of the left lower lobe is to the subadjacent peribronchial nodes and to the interlobar sump nodes. From here, drainage is to the hilar or mediastinal lymph node groups or both.
Lymphatic drainage from the middle and right lower lobes and the left lower lobe also occurs to the nodes on the pulmonary ligament. These lymph nodes belong to the mediastinal nodes. The incidence of nodes identified in Borrie's work (1965) was 12% in the right pulmonary ligament and 47% in the left.

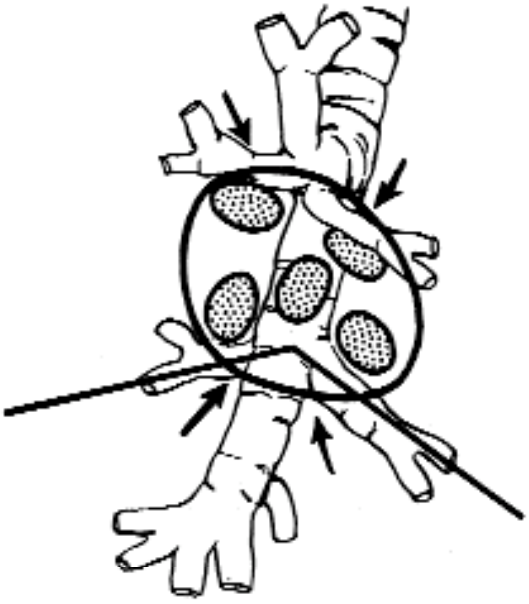

Fig. 1: Right lymphatic sump.

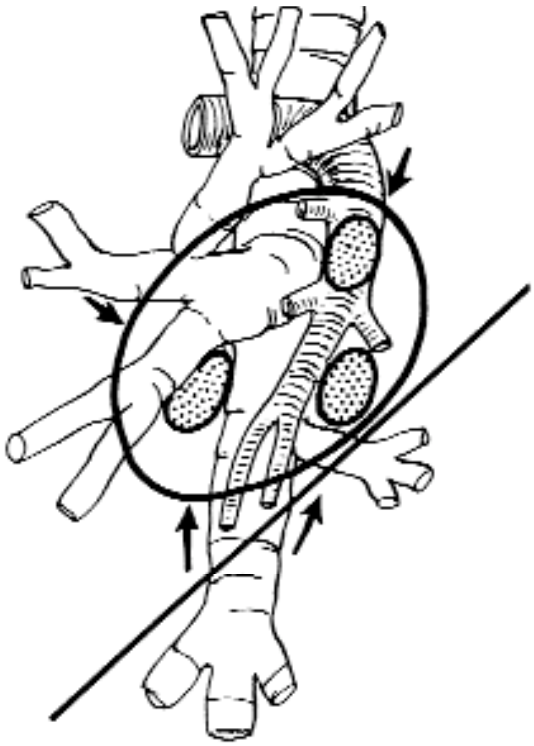

Fig. 2: Left lymphatic sump. From: Shields TW: General Thoracic Surgery, 1994.

Mediastinal lymph nodes

They are grouped into anterior prevascular nodes, tracheobronchial nodes, paratracheal nodes and posterior nodes (Fig. 3, 4, Tab. V).

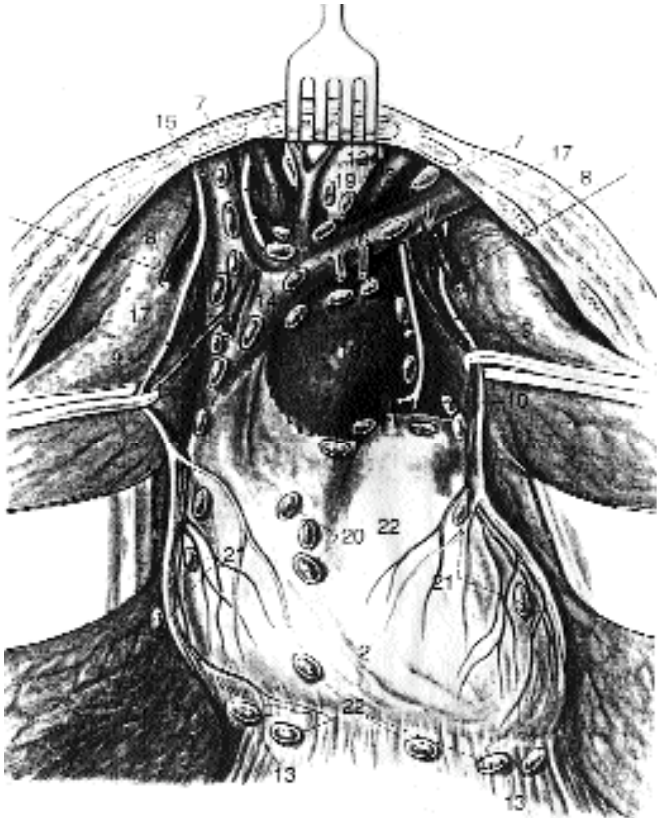

Fig. 3: Anterior mediastinal lymph nodes. From: Kremer K: Chir. Op.Lehre Bd. 2, Thieme, Stuttgart, 1991. Vorderer Abschnitt des oberen und unteren Mediastinums und Verteilung der Lymphknoten. 1 Pleura mediastinalis; 2 Pericardium (fibrosum); 3 Arcus aortae; 4 Truncus branchiocephalicus; 5 A. carotis communis dextra; 6 A. carotis communis sinistra; 7 A. subclavia; 8 A. thoracica interna; 9 A., V. pericardiacophrenica, N. phrenicus; 10 N. vagus sinister, N. laryngeus recurrens sinister; 11 N. vagus dexter, N. laryngeus recurrens dexter; 12 Trachea; 13 Diaphragma; 14 V. cava superior; 15 V. brachiocephalica dextra; 16 V. brachiocephalica sinistra; 17 V. thoracica interna; 18 Nodi lymphatici mediastinales anteriores; 19 Nodi lymphatici tracheobronchiales superiores; 20 Nodi lymphatici pericardiales; 21 Nodi lymphatici pericardiales laterales; 22 Nodi lymphatici phrenici superiores.

Tab. Va – MEDIASTINAL (EXTRAPULMONARY) LYMPH NODES

• Anterior (prevascular)	anterior mediastinal compartment	
• Tracheobronchial	right and left superior inferior (subcarinal)	
• Paratracheal		
• Posterior	paraoesophageal pulmonary ligament	visceral mediastinal compartment
• Subaortic		
• Paraaortic		

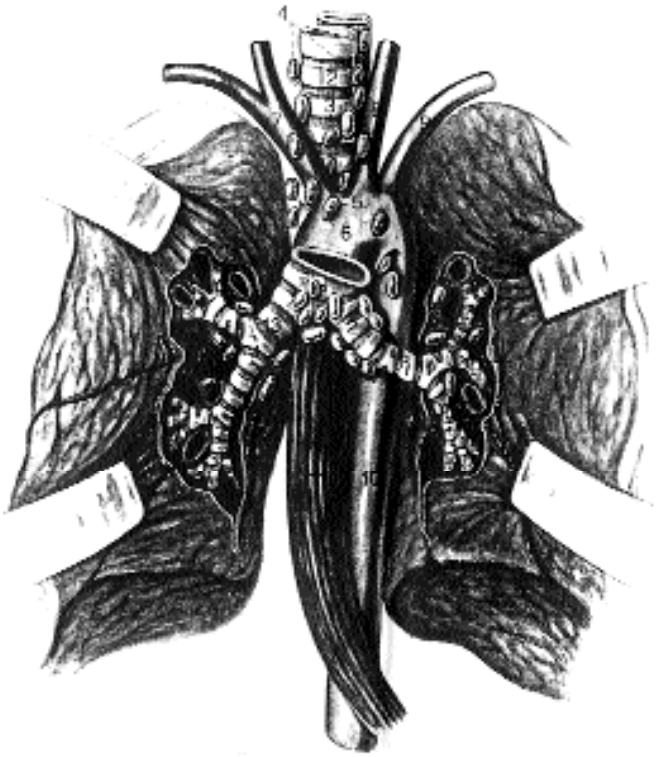

Fig. 4: Tracheal and bronchopulmonary lymph nodes. From: Kremer K: Chir. Op. Lehre Bd. 2, Thieme, Stuttgart, 1991. Tracheale und bronchopulmonale Lymphknoten von vorne. 1 Nodi lympatici bronchopulmonales (hilares); 2 Nodi lympatici tracheobronchiales inferiores; 3 Nodi lympatici tracheobronchiales superiores; 4 Nodi lympatici paratracheales; 5 Nodi lympatici mediastinales anteriores; 6 Arcus aortae; 7 Truncus brachiocephalicus; 8 A. carotis communis sinistra; 9 A. subclavia sinistra; 10 Pars descendens der Aorta thoracica; 11 Ösophagus; 12 Trachea; 13 Bronchus principalis dexter.

Anterior mediastinal lymph nodes

These lymph nodes are in the prevascular compartment of the mediastinum. They are found at the upper portions of the pericardium and great vessels. On the right side, the nodes lie parallel and anterior to the right phrenic nerve. They extend upward to and along the superior vena cava to the area beneath the right innominate vein. On the left, they are near to the origin of the pulmonary artery and to the ligamentum arteriosum They extend upward near the left phrenic nerve to lymph nodes along the inferior border of the left innominate vein in the region where it is joined by the left superior intercostal vein.

Tracheobronchial lymph nodes

These nodes lie in three groups about the bifurcation of the trachea. The right and left superior tracheobronchial nodes are located in the obtuse angles between the trachea and the corresponding main stem bronchus. These

nodes lie outside of the pretracheal fascia. The lymph nodes of the right superior tracheobronchial group are medial – beneath – the arch of the azygos vein and above the right pulmonary artery. These nodes are contiguous with the right superior hilar nodes distally and the right paratracheal nodes proximally. The left superior tracheobronchial nodes lie deep within the concavity of the aortic arch. Some are closely related to the left recurrent laryngeal nerve, others are situated slightly more anteriorly and are contiguous with the node at ligamentum arteriosum and the root of the left pulmonary artery. Their association with these nodes constitutes the link between the nodes in the visceral compartment and those in the anterior mediastinal lymph node group.
The inferior tracheobronchial nodes – commonly known as subcarinal nodes – lie in the angle of the bifurcation of the trachea. Although these nodes, in contrast to the superior tracheobronchial groups, lie within the pretracheal fascial envelope, they are outside the bronchopericardial membrane. These nodes are contiguous with the hilar nodes on the medial aspect of the right and left main stem bronchi. Some subcarinal nodes lie more posteriorly in relationship to the tracheal bifurcation and are on the anterior surface of the esophagus, in this way connected with the posterior group of lymph nodes. There is also a low anterior tracheal group lying in front of the lower end of the trachea, which is a connection between the right superior tracheobronchial lymph nodes and the subcarinal – inferior tracheobronchial – lymph nodes (Brock and Whytehead 1955).

Paratracheal lymph nodes

These lymph nodes are on the right and left sides of the trachea above the superior tracheobronchial nodes, extending upward along the trachea. The right paratracheal lymph nodes lie anterolaterally to the trachea and to the right of the innominate artery. Inferiorly, these nodes are overlapped by the superior vena cava. More superiorly, these nodes are behind and above the innominate artery to the right of the midline of the trachea. At the left side the paratracheal nodes lie above the tracheobronchial angle to the left of the midline of the trachea behind the aortic arch. To the chest inlet, they are situated above the arch behind the great vessels.

Posterior mediastinal lymph node

These nodes are separated into two groups: the paraesophageal nodes and those located in the pulmonary ligaments. The paraesophageal nodes are more numerous in the inferior portion of the mediastinum and are found more frequently on the left than on the right side.
The inferiorly located nodes have connections with the para-aortic nodes beneath the diaphragm. In the pulmonary ligaments, usually two or more small lymph nodes can be found. A relatively constant node, lies in close proximity to the inferior border of the inferior pulmonary vein. It is often termed as the sentinel node.

Number and Size of Mediastinal Lymph Nodes

Some main publications are listed below (Tab. Vb). Glazer (1985) from CT and Kiyono (1988) at cadaver specimens found nearly similar results. From these data it was suggested that 10 mm be considered the upper limit for the short axis of normal mediastinal lymph nodes. Also in Kondo's (1990) findings with ultrasound most nodes considered normal were less than 1 cm in size (97%).

Lymphatic Drainage of the Lungs to the Mediastinal Lymph Nodes

Despite variations in terminology of lung structurs and node stations in multiple studies relatively consistent "normal" drainage patterns for each lung and its lobes and segments could be identified. One of the basic studies of lymphatic pathways was published by Hoffmann (1959). He used the injection technique by Geroto (1896) into the Stratum subpleurale.
Important findings were:
– Lymphatic connections deep in the fissures between neighbouring lobes
– Connections between the superficial subpleural network and the deep system of the lung but also with interlobar nodes
– Lymphatic vessels run along arteries, bronchi of a lobe and interlobar and intersegmental septa of connective tissue

Tab. Vb – NUMBER AND SIZE OF MEDIASTINAL LYMPH NODES SHIELDS 1994

- Beck and Beattie (1958):
  Autopsies
  3 nodes anterior mediastinum
  50 nodes tracheobronchial region (16 peribronchial, 11 subcarinal, 23 paratracheal)

- Glazer et al. (1985)
  56 CT cases
- Kiyono et al. (1988)
  40 Cadaver cases
- Kondo et al. (1990)
  Transesophageal ultrasound (TEUS) vs. CT

Most lymph nodes considered normal were less than 10 mm in size - 97%. (Shields 1994)

– Node stations of a lobe are at the lobar bronchus but also interlobar nodes (sump!)
– It is supposed that the lymph apparatus of a neighbour lobe is only used if lymph flow at the lobar hilus is inhibited by a pathological process (retrograde flow to the neighbour lobe)
- At the hilum of the lung lymphatic pathways run along main bronchus and pulmonary artery. Upper and lower region of the main bronchus is preferred.
There are 4 pathways:
– Upper bronchial drainage
– Lower bronchial drainage
– Interlobar drainage along Fissura interlobaris
– "Most" nodes

Upper bronchial pathway

Collects lymph mainly from the upper lobe. Right it reaches the tracheobronchial nodes. Left there are nodes at the upper circumference of the pulmonary artery. The further way is divided to the tracheobronchial nodes and to the so-called Most nodes.

Lower bronchial pathway

Runs along the lower circumference of the main bronchus. It collects the lymph from the middle and lower lobe, but also vessels from the ligamentum pulmonale. It reaches the bifurcation nodes.

Interlobar pathway along Fissura interlobaris

Collects lymph from all neighbour lobes near the fissures and interlobium; the first station are the interlobar nodes. Deep in the fissures are connections to the subpleural net. In the further course the next interlobar nodes are not crossed, but regularly jumped.

Interlobar pathway reaches the tracheobronchial and bifurcation nodes. At the left side there is a "bypass" through the Most nodes. Therefore also lymph from the middle and lower lobe drains to these nodes tracheobronchial.

4th way Most nodes

It exists from both lungs. Collects lymph from superficial net of the mediastinal surface of the upper lobe to the upper lingula segment. Also a part of the deep vessels goes this way.
The Most nodes cross the aortic arch between N. phrenicus and N. vagus. At the right side lymphatic way runs medial and lateral of the V. azygos to the paratracheal nodes.
The dynamic study by use of lymphoscintigraphy in normal healthy subjects as reported by Hata (1981, 1990) demonstrates a highly satisfactory scheme. The patterns and 4 left lung maior routes are shown in Fig. 5.

Significance of the Lymphatic Drainages Patterns

The routes as described by Hata (1990) agree in most details with the patterns described by Rouvière (1932) and Nohl (1956). Significant features of the lymphatic drainage from the various lobes of the lungs to the mediastinal lymph nodes are pointed out in Tab. VI - e according to Shields (1994).
Some special findings are the following:
Ad 6: "Direct pathways" (Riquet 1989)
The subpleural lymphatics of 483 lung segment were injected in cadavers of 260 adult subjects. The injected lymph vessels corresponded to the pulmonary segmentation in 9I % of the cases and remained close by in the other cases. Direct passages to the mediastinal nodes were

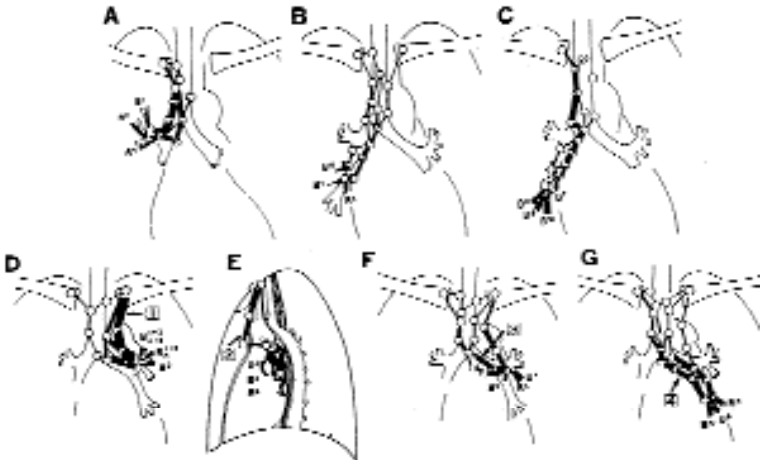

Fig. 5: Standard patterns of lymphatic drainage of the lungs (Hata 1990). From: Shields T.W.: General Thoracic Surgery, 1994.

Tab. VI – SIGNIFICANCE OF LYMPHATIC DRAINAGE PATTERNS (Shields 1994)

1. Drainage from right lung essentially unilateral.
   Crossover infrequent:
   → Left paratracheal n.
   → Left anterior n.

   Seldom right basal segments
   → Left pulmonary ligament
   (Riquet 1989)

2. Contralateral drainage from left lung relatively common.
   • Most frequently via subcarinal n.
   • Occasionally via lower pretracheal n. (from lower lobe)
   • Direct channel between left and right paratracheal n. and between left lower lobe and right inferior mediastinum. (Riquet 1989)
   • Crossover was also described by Franke 1926, Rouviére 1932; in BC by Nohl-Oser 1956, Maassen and Greschuchna 1973

3. Drainage from lower lobes to ipsilateral superior mediastinal n. common.

4. Drainage to subcarinal n. from right upper lobe does occur: 13-14%
   (Rouviére 1932, Nohl 1962, Nohl-Oser 1972, Borrie 1965, Hata 1981, 1990, Riquet 1989, Watanabe 1990, Libshitz 1986)

5. Drainage of superior portion of left upper lobe to subcarinal n. unusual, but from lingula common. (Hata 1981)

6. Direct lymphatic channels from either lung to mediastinal n. can bypass bronchopulmonary n.: "Skip metastases"
   (Martini 1987, Libshitz 1986, Ishida 1990)

   Direct channels exist between subpleural plexus to mediastinal n. (Riquet 1989):
   Right lung 22%, Left lung 25%

7. Lower lobes to both lungs to ipsilateral pulmonary ligament n. -> inferior paraesophageal n. (Borrie 1952)

8. Drainage from superior mediastinal n. -> scalene n., right > left

9. Drainage from lower mediastinal regions -> para-aortic n. and suprapancreatic n. (Hoffmann 1959)

   Direct channel between basal segments of both lungs to juxta celiac n. (Riquet 1988, 1990; Meyer 1958, Hoffmann 1959)

observed in 54 of 243 right lung segments injected (22,2%) and 60 of 240 left lung segments (25%). In all of the other cases the dye followed classic pathways ad filled the bronchopulmonary lymph nodes. In 9% the dye diffused into one or two contiguous segments. This contiguous segments may form a translobar passage by a parenchymatous transfissural bridge. Direct contralateral lymph pathways were observed five times, four of them from basal segments of lower lobes.

Ad 9: Hoffmann (1959) found the following routes to abdominal nodes:
– Paraoesophageal nodes mostly from the lobes directly or through a Sig. pulmonale nodes and further to suprapancreatic nodes or paraaortic nodes and further to D. thoracicus.
– Direct pathway from lower lobe to above mentioned nodes below the diaphtagma.
The clinical relevance of the lymphatic drainage and the various lymph node groups for metastasis of lung cancer was examined in the last decades by many authors. Since introduction of mediastinoscopy a new concept of lymphatic drainage of the lung was established based on the former anatomical and "normal studies". Profound descriptions are from Nohl-Oser (1972), Greschuchna and Maassen (1973) and several other authors.
Fig. 6 lists the patterns of metastatic spread dependent from cancer location comparing the results of Nohl-Oser and Maassen. (International Trends in General Thoracic Surgery: Lung Cancer 1985).
A practical synopsis is shown in Fig. 7a, b (Nohl 1956, 1985).
The "uncertainties" of node locations and lymphatic pathways with respect to lymphogenic metastases of lung cancer are listed below according to Schirren (1996):
– Number of nodes and pathways individually varifying, therefore anatomical compartments for mapping necessary;
– Lymph flow usually centripetal; retrograde flow possible (eg. tumor obstruction scars, silicosis) Riepert and Muller 1986 → Skipping;
– Cross over (Rouvière 1932, Nohl-Oser 1956, Greschuchna and Maassen 1973);
– Direct clannels subpleural → mediastinal nodes (right 22%, left 25%) Riquet 1989;
– Metastatic lymph flow difficult to be calculated;
– Topographical lymph nodes with flow cranial and caudal or to the contralateral side can be skipped or in retrograde direction be involved (Schirren 1996);
– Patterns of spread from tumors of the lobes are relatively constant (Shields 1994), but following "uncertainties":
– Skip metastases in mediastinal nodes in 29% (Libshitz 1986, Martini 1983, 1987, Ishida 1990) Pathways herefore described by many of the early investigators of lymphatic drainage, also by Riquet (1989);
– Upper lobe tumors → 11% positive subcarinal nodes (Watanabe 1990);
– Contralateral spread: (Nohl-Oser):
Right upper lobes 4%;
Right lower lobes 5%;
Left upper lobes 9,3%;
Left lower lobes 28%.
Total 21% (Greschuchna and Maassen 1973).
Dependent from cell type (Hata 1990) and size of the tumor (Ishida 1990).
Supraclavicular and cervical lymph node metastasis 16%

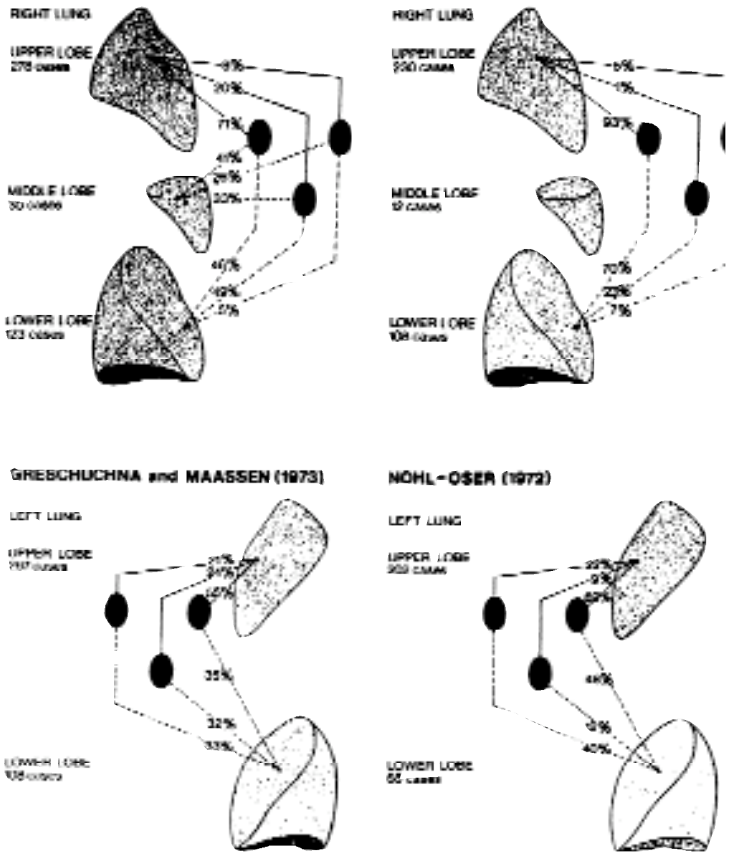

Fig. 6: Patterns from metastatic spread of bronchial carcinoma. From: Massen 1985.

Para-aortic nodes below diaphragm 8% (direct connections lung-paraortic
Riquet 1988, 1989)

Mediastinal lymph node mapping

Naruke (1978) suggested the use of an anatomic map with the conventional lymph node stations numbered. So the various lymph node stations involved by metastasis could be uniformly recorded in bronchogenic carcinoma. The American Joint Commitee for Cancer Staging and End Results Reporting (AJC) published a similar report in 1983. The American Thoracic Society (ATS) (Tisi 1983) recommended that the hilar stations (right of the Naruke and AJC) be deleted because of the ambiguity of the radiologic definition of these areas. It was soggested to define these areas as peribronchial on the left and tracheobronchial at the right and be assigned to the mediastinal compartments outside the pleural reflection. Because there are great variations of the number of nodes at the defined stations of the N1 and N2 region, for surgical reasons anatomical compartments are defined namely cranial and caudal mediastinal com-

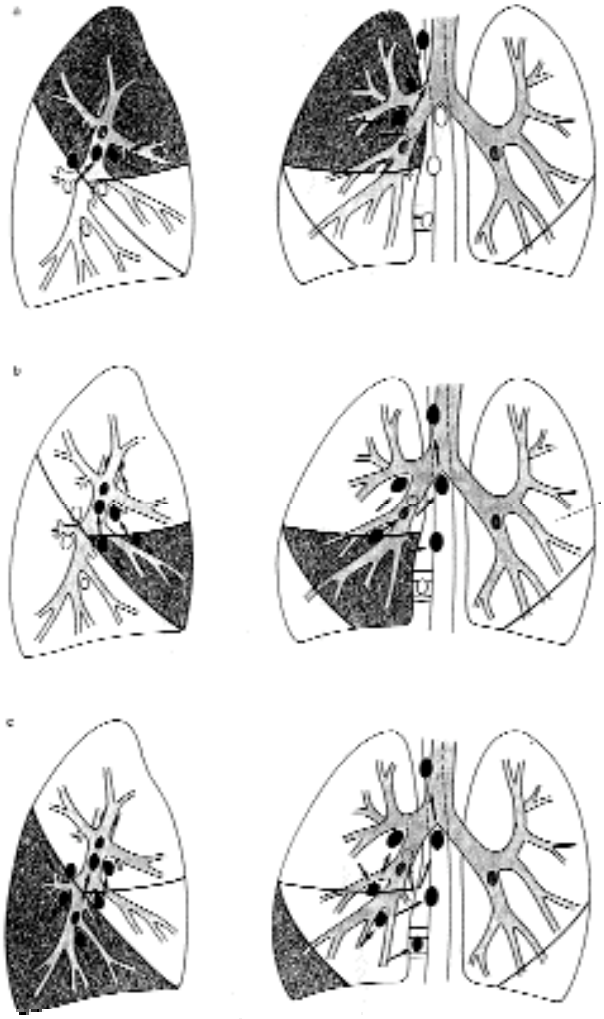

Fig. 7a: Lymphatic drainage right lung. From: Nohl-Oser HC, 1985.

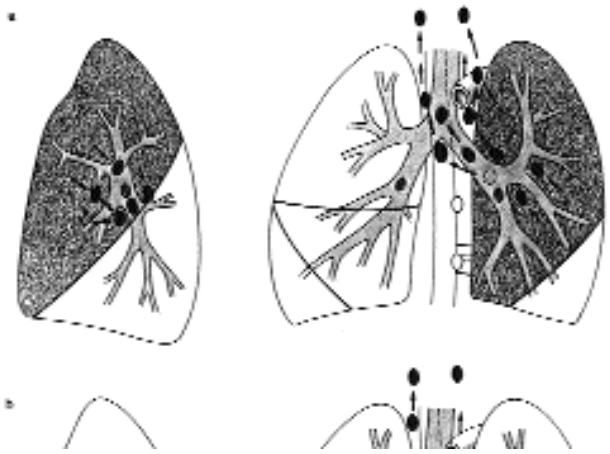

Fig. 7b: Lymphatic drainage left lung. From: Nohl-Oser HC, 1985.

partment. On the right the border is the V. azygos. On the left the cranial compartment includes the paratracheal, tracheobronchial, paraaortic and sub aortic nodes; the caudal the bifurcation, paraoesophageal and Lig. pulmonale nodes.

Knowledge of anatomical and clinical facts of the lymphatic drainage pathways between lung and mediastinum and metastatic spread patterns of lung cancer form the basis for the modern TNM-classifications for staging of lung cancer since 1970!

References

1) Borrie J.: *Primary carcinoma of the bronchus: Prognosis following surgical resection.* (Hunterian Lecture) Ann R Coll Surg Engl, 1952, 10:165.

2) Borrie J.: *Lung Cancer: Surgery and Survival.* New York: Appleton-Century-Groft, 1965.

3) Bülzebruck H., Bopp R., Drings P., Bauer E. et al.: *New aspects in the staging of lung cancer.* Cancer, 1992, 70:1102.

4) Genereux, G.P., Howie J.L.: *Normal mediastinal lymph node size and number: CT and anatomic study.* Am J Roentgenol, 1984, 142:1095.

5) Glazer G.M., et al.: *Normal mediastinal lymph nodes: Numer and size according to American Thoracic Society mapping.* Am J Roentgenol, 1985, 144:261.

6) Greschuchna D., Maassen W.: *Die lymphogenen Absiedlungswege des Bronchialkarzinoms.* Stuttgart: Georg Thieme, 1972.

7) Hata E. et al.: *Rationale for extended lymphadenectomy for lung cancer.* Theor Surg, 1990, 5:19.

8) Hata E., Troidl H., Hasegawa T.: *In vivo Untersuchungen der Lymphdramage des Bronchialsystems beim Menschen mit der Lympho-Szntigraphie. Eine neue diagnostische Technik.* In Hamehnann H., Troidl H. (eds.): *Behandlung des Bronchialkarzinoms.* Stuttgart: Georg Thieme, 1981.

9) Hoffmann E.: *Die Abflubwege der Lymphe und ihre Bedeutung für die Ausbreitung maligner Tumoren.* Bruns Beitr Klin Chir, 1959, 199:451.

10) Ishida T. et al.: *Strategy for lymphadenectomy in lung cancer three centimeters or less in diameter.* Ann Thorac Surg, 1990, 50:708.

11) Junker K., Müller K.M.: *Metastasierung beim Bronchialkarzinom.* Z Herz Thorax Gefäbchir, 1989, 13:189.

12) Kiyono K. et al.: *The number and size of the mediastinal lymph nodes: A postmortem study.* Am J Roentgenol, 1988, 150:771.

13) Kondo D. et al.: *Endoscopic ultrasound examination for media - stinal lymph node metastases of lung cancer.* Chest, 1990, 98:587.

14) Kremer K. et al.: (Ed) Chir. Op.lehre - Thorax, Thieme, Stuttgart, 1991.

15) Kubik S.: *Anatomie der Lymphgefäbe der Lunge.* In: Eckert P. (Hrsg) *Intensivmedizin Anaesthesiologie, Bd 2: Volumenregulation und Flüssigkeitslunge.* Thieme Stuttgart, S 10, 1976.

16) Libshitz H.I., McKenna R.J., Mountain C.F.: *Patterns of media - stinal metastasis in Bronchogenic carcinoma.* Chest, 1986, 90:229.

17) Martini N., Flehinger B.J.: *The role of surgery in N2 lung can - cer.* Surg Clin North Am, 1987, 67:1037.

18) *Manual for Staging Cancer:* American Joint Committee for Cancer Staging and Endresults Reporting. Chicago, 1983.

19) Maassen W.: *Accuracy of Mediastinoscopy.* In: Delarue N.C., Eschapasse H., *International Trends in General Thoracic Surgery - Lung Cancer*, W. B. Sounders, Philadelphia, 1985.

20) Meyer K.K.: *Direct lymphatic connections form the lower lobes of the lung to the abdomen.* J Thorac Surg, 1958, 35:726.

21) Naruke, T.: *Surgical treatment for lung cancer with metastasis to mediastinal lymph nodes.* J Thorac Cardiovasc Surg, 1976, 71:279.

22) Naruke T., Suemasu K., Ishikawa S.: *Lymph node mapping and curability at various levels of metastasis in resected lung cancer.* J Thorac Cardiovasc Surg, 1978, 76:832.

23) Naruke T.: *Mediastinal lymph node dissection.* In: Shields T.W. (ed.) *General thoracic surgery, Vol. 1, 4th edn.* Williams & Wilkins, Baltimore Philadelphia Hong Kong, 1994.

24) Nohl H.C.: *An investigation into the lymphatic and vascuar spread of carcinoma of the bronchus*, Thorax, 1956, 11:172.

25) Nohl-Oser H.C.: *An investigation of the anatomy of the lympha - tic drainage of the lungs.* Ann R Coll Surg Engl, 1972, 51:157.

26) Nohl-Oser H.C.: *Lungenchirurgie.* Thieme, Stuttgart, 1985.

27) Riepert T., Müller K.M.: *Tumorausbreitung in Lungen mit Silikosen.* Verh Dtsch Ges Patho, 1984, 68:407.

28) Riquet M., Hidden G., Debesse B.: *Abdominal nodal connec - tions of the lymphatics of the lung.* Surg Radiol Anat, 1988. 10:251.

29) Riquet M., Hidden G., Debesse B.: *Direct lymphatic drainage of lung segments to the mediastinal nodes. An anatomic study of 260 adults.* J Thorac Cardiovasc Surg, 1989, 97:623.

30) Rouvière H.: *Anatomie des Lymphatics de le homme.* Paris: Masson et Cie, 1932.

31) Schirren J. et al.: *Grundlagen und Ergebuisse der systematischen*

Lymphknotendissektion beim operierten Bronchialcarcinom. Chirurg, 1996 , 67:869.

32) Shields T.W.: *Lymphatics of the Lungs.* In: Shields T.W. (ed.): General Thoracic Surgery, Vol. I, 4. ed., Williams and Williams, Baltimore, 1994.

33) Tisi G.M. et al.: *Clinical staging of primary lung cancer.* Am Rev. Respir Dis, 1983, 127:659.

34) *UICC and AJCC: TNM-Supplement.* Springer, Heidelberg New York, 1994.

35) Watanabe Y. et al.: *Mediastinal spread of metastatic lymph nodes in bronchogenic carcinoma. Mediastinal nodal metastases in lung cancer.* Chest, 1990, 97:1059.