

LUNG PERFUSION SCINTIGRAPHY IN PULMONARY CARCINOMA AND PULMONECTOMY

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ABSTRACT

PURPOSE: The surgical treatment is the most successful treatment of non-small cell lung cancer (NSCLC) in oncology practice. Lung perfusion scintigraphy as a non-invasive method for evaluation of the perfusion defect related to tumor localization in lung cancer patients is considered the differentiating line of pulmonary tests to predict post-operative lung function.

MATERIALS AND METHODS: We analyzed retrospectively the value of lung perfusion scintigraphy in 10 cases with primary lung carcinoma who had a pneumonectomy (9 left and 1 right pneumonectomy).

RESULTS: Changes in affected lung perfusion varied from impaired in different rate to perfusion defect in at least 3 lung segments (presented in 3 of the patients), 4 lung segments (present in 2 of the patients), or parts of segments, or defect affecting whole lobe. Impaired perfusion in a zone with polycyclic outlines in homolateral hilum was present in 7 of the patients. Perfusion indices at localization in the left lung (8 of the patients) were mean = 36,79%, SD=19,35%, SE=6,8%.

CONCLUSION: Lung perfusion scintigraphy is a valuable method in the complex of pre-operative examinations to define the extent of the impairments in pulmonary perfusion and predicting the post-operative pulmonary function when pneumonectomy is about to be elaborated. The rate of perfusion changes and the percentage of involvement of the affected lung in the common pulmonary function correlate with survival. The low perfusion in the affected lung is not necessarily a contraindication for operative treatment.

Key words: lung carcinoma, lung perfusion scintigraphy, pneumonectomy

INTRODUCTION

The surgical treatment is the most successful treatment of NSCLC in oncology practice. For the selection of candidates for surgical treatment it is most important to assess the extent of biologic invasion

of the cancer process and the borders of its regional proliferation. Lung perfusion scintigraphy is non-invasive, physiological method with low radiation burden to determine the changes in pulmonary bloodstream and for evaluation of the size of perfusion defect in relation to tumor localization in patents with lung carcinoma. It is considered differentiating line of the pulmonary tests to predict the post-operative pulmonary function when pneumonectomy is going to be elaborated (2,15).

MATERIALS AND METHODS

We analyzed retrospectively 10 consecutive cases with primary lung carcinoma treated in our de-

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partments. Every patient was subjected to a standard postero-anterior and lateral chest X-ray, fiberoptic bronchoscopy and to some of them chest CT. There were 9 men and 1 woman. The age range was from 42 to 64 years. The tumor was located in the right lung in 1 patient and in the left lung in the remaining 9 cases. Lung perfusion scintigraphy was performed in all patients with ^{99m}Tc - human albumin microspheres with a particle size of 23-45 μm (kit Sferotec – Sorin Biomedica-Italy). The injection was applied in supine position, intravenously in bolus, 1ml at an activity of 55-74MBq. The period of examination was between the 15th min and the 2nd hour after injection, at anterior, posterior, lateral and 45° detection, perfusion indices from 6 fields in front and posterior projection were calculated (Picker Dyna Camera 4 Scintillation Camera System – Picker Corporation Nuclear and Ultrasound, USA).

We considered 4 pathological criteria for interpretation of lung perfusion scintigraphy:

1. Absent or minimal perfusion of the affected lung or a perfusion defect less than 1/3 of the affected lung.
2. Perfusion defect and enlargement of the hilum of the affected lung.
3. Enlargement and displacement of the mediastinum in anterior and/or posterior detection.
4. Perfusion defect in the contralateral hilum.

Pneumonectomy was performed at 10 patients. An invasive staging with mediastinoscopy before pneumonectomy was not performed. The patients were staged in accordance with TNM classification ⁸.

RESULTS

All patients with pneumonectomy were staged pre-operatively by noninvasive procedures at stages I-IIIa. The presence of NSCLC histology and performance status (Karnofsky index = 70-80). The lung perfusion scintigraphy demonstrated an enlarged mediastinum in front and posterior projection at 1 of the patients. Impaired perfusion in a zone with polycyclic outlines in homolateral hilum was present in 7 of the patients. Impaired perfusion in the contralateral hilum was found in 2 of the patients. Changes in affected lung perfusion varied from impaired in different rate to perfusion defect in at least 3 lung

segments (presented in 3 of the patients), 4 lung segments (present in 2 of the patients), or parts of segments, or defect affecting whole lobe. No patient with perfusion defect involving less than 1/3 of the affected lung, a sign indicating unresectability was found (11,12). Perfusion indices at localization in the left lung (8 of the patients) were mean=36,79%, SD=19,35%, SE=6,8%.

On Fig 1 is presented lung perfusion scintigraphy of man, 57 years of age with final diagnosis: Carcinoma pulmonis sin., T3N2M0 – III clinical stage. Histology: moderately differentiated spinocellular carcinoma with metastases in subaortic, mediastinal and bifurcation lymph nodes. During bronchoscopy a carcinoma in 4th segment of left lung was found. X-ray: shadow between 6 and 7 rib in posterior pro-

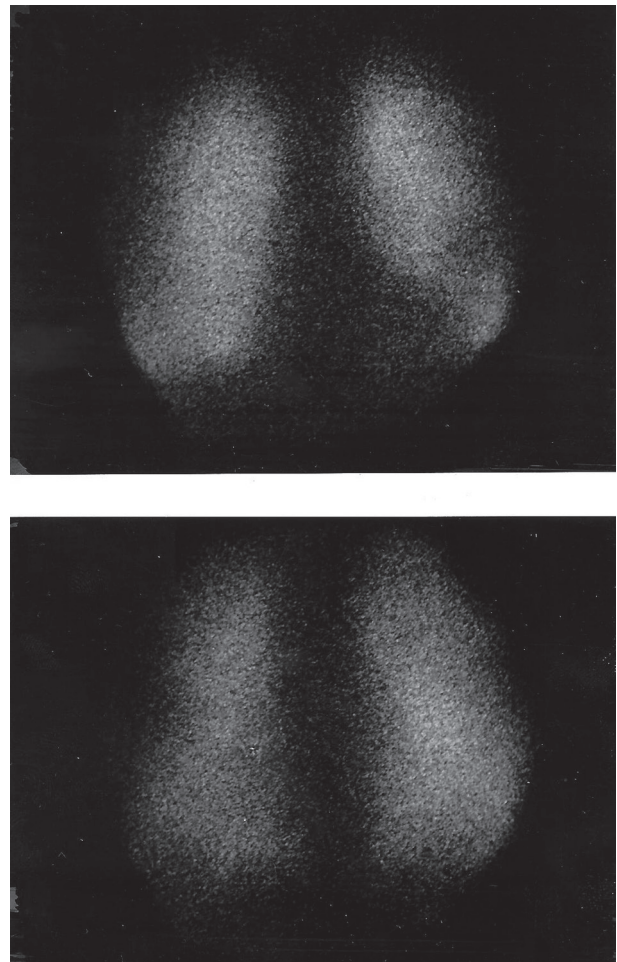


Fig.1. Lung perfusion scintigraphy in front and posterior projection before operation of a man of 57 years of age with diagnosis: Carcinoma pulmonis sin. T3N2M0 – III clinical stage.

jection, 5cm/5cm with non-homogenous density and unclear polycyclic borders. CT found irregular formation in left median lung field with sharp and uneven lines, connected with the hilum, with density 40 H.E. and size 48mm/33mm. Conclusion: Peripheral carcinoma on the left. From lung perfusion scintigraphy it was found perfusion defect in the region of 4, 5 and 8 segments in the left lung, impaired perfusion in a zone with polycyclic lines in left hilum, enlarged mediastinum and uncertain data for perfusion changes in right hilum. Perfusion indices: right lung – 55,5%, left lung – 44,5%. Intra-operatively a tumor formation with diameter 8 cm was found. It spread to 4 and 5 segments, infiltrating 8 segment. In the mediastinum under and over arcus aortae, under aorta descendens and in the tracheal bifurcation

were found lymph nodes with size 1-2 cm in diameter. Operation: Left pulmonectomy with mediastinotomy and extirpation of lymph nodes.

Only the lung perfusion scintigraphy detects perfusion changes in 8th segment, evidenced intraoperatively as proliferation of the tumor there.

On Fig. 2 is presented the lung perfusion scintigraphy of the same patient 7 months after the operation and after chemotherapy treatment – in right hilum is found a zone with polycyclic lines and impaired perfusion – we suppose presence of enlarged lymph nodes in this zone.

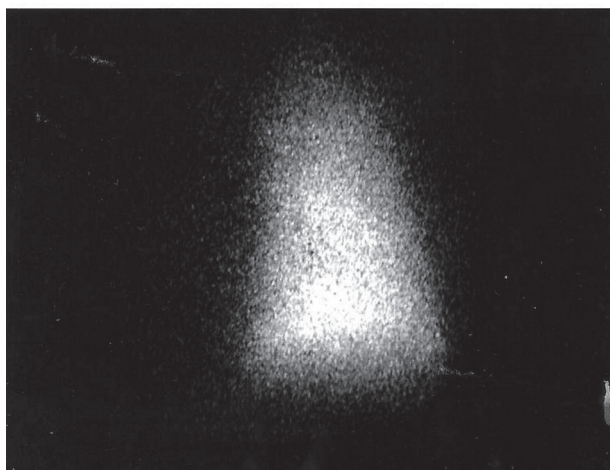
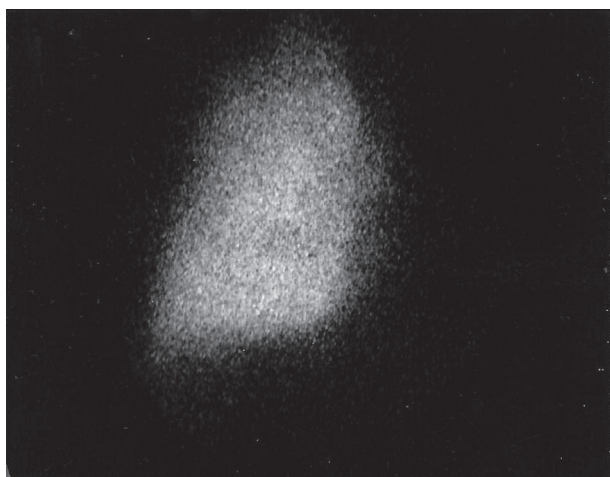


Fig. 2. Lung perfusion scintigraphy in front and posterior projection of the patient from Fig. 1. seven months after left pulmonectomy

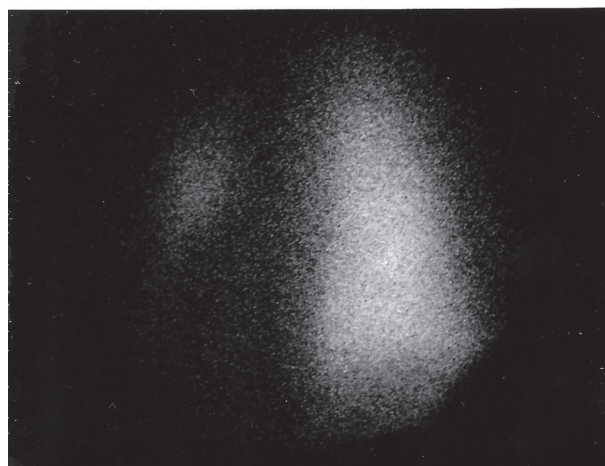
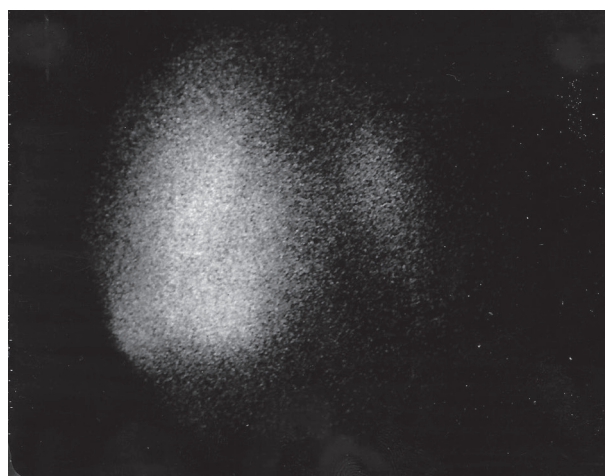


Fig. 3. Lung perfusion scintigraphy in front and posterior projection of a man of 56 years of age before operation with diagnosis: Adenocarcinoma of the left lung T3N2M0. Pneumosclerosis after bi-lateral tuberculosis and artificial left pneumothorax.

Lung perfusion scintigraphy after pneumonectomy was performed at 2 patients, 7-8 months after the operation. At patient 2 the right lung is with changed form, uneven and uncertain borders, part of the segments are projected in left chest half, the intake of radiopharmaceutic is strongly intensive and non-homogenous.

Particular difficulty represent the patients at whom the tumor process is combined with preceding illness, when there is a previous operation of the lungs and a recurrence of the carcinoma is searched.

On Fig. 3 is presented lung perfusion scintigraphy of a man, 56 years of age with diagnosis: Adenocarcinoma of left lung - T3N2M0. Pneumosclerosis after two-sides tuberculosis and artificial pneumothorax on the left. At bronchoscopy the left major bronchus is with hyperemia, bronchi of the upper lobe are with hyperemia and deformed and the bronchus of the lower-lobe is obturated by a polyposis formation. X-ray: deformation of the chest – stenosis of the left hemi-thorax with deviation of mediastinal structures with pulling of the trachea on the left. Decreased transparency of the left hemi-thorax, dense shade of the left cupola, plaques with bone density on the pleura and in its basis under 7th rib in posterior projection – dense shadow with upper convexity. Lung perfusion scintigraphy: The mediastinum is dislocated to the left, in the right lung apically in front projection the perfusion is impaired to extent of perfusion defect, in the left lung perfusion is lacking while an elliptic zone of impaired perfusion is visualized around the hilum. Perfusion indices: right lung – 88,3%, left lung – 11,7%. Intra-operatively in the lower lobe a tumor formation with size of 10cm in diameter is found, the rest lung parenchyma is pneumosclerotic, airless, and pleural sheath is thickened in some spots to 2 cm with bone plaques. Left pneumonectomy is elaborated with extirpation of lymph nodes in mediastinum.

All 10 patients were operated on. Pneumonectomy has been elaborated in cases with central lung carcinoma with or without presence of lymph metastases in the hilum and in the mediastinum, in tumor with every localization but with homolateral hilar and mediastinal lymph metastases and tumor proliferating and expanding over the hilar elements when their processing is possible. There is a good correla-

tion between the rate of decreased perfusion of the lung and the presence of enlarged lymph nodes and nodal metastases in hilar and mediastinal lymph nodes. Determination of the values of postoperative parameters of pulmonary function we have evaluated by lung perfusion scintigraphy.

DISCUSSION

About 70% of the patients with lung carcinoma have chronic obstructive pulmonary disease (COPD) and about 20% of them are with significant impair of pulmonary function. Olsen G.N. et al. (10) recommend perfusion scintigraphy as simple and practical method to determine the one-side pulmonary function before pneumonectomy.

Kim J-K. et al. (6) find that pre-operative FEV₁ and number of resected segments are the significant clinical factors, which influence the accuracy of the index of prediction of post-operative pulmonary function. It is significantly better when it is based on lung perfusion scintigraphy than to simple calculation.

Lung perfusion scintigraphy is a sensitive indicator when tumors are located next to hilum, but far less when the tumor is in lung periphery. The X-rays in central bronchial carcinomas are negative in 12% while scintigraphy has been positive in all of the cases and has shown significant perfusion impairs. However with scintigraphy localization of peripheral tumor has been accurate only in 50% of the cases (5).

Lung perfusion scintigraphy in central stenosis diagnosed by bronchoscopy could show pathologic reduction of the perfusion values. The reduction of the perfusion is more expressed than the reduction of ventilation and is high-rate at lobar and bi-lobar cases, while in segment infiltration the values of both methods are in the normal range. Parenchymal infiltration has greater importance than bronchial obstruction for the reduction of the pulmonary perfusion and ventilation (16).

Levcheva V. et al. (7) in examination of patients with central bronchial carcinoma found defects in perfusion adequate to hypo-ventilated zones, which gives the opportunity to predict the size of the planned pulmonary resection. They consider that diagnostic potential of perfusion lung scintigraphy exclude or indicate additional invasive methods to diagnose pulmonary diseases.

Datta D. et al. (3) consider that lung perfusion scintigraphy and determination of perfusion indices of every lung as a more than necessary instrument in the pre-operative assessment of the patients with high risk for pulmonary resection.

In cases with central tumors when the perfusion of the affected lung is less than 25% from the common perfusion, probably the lesion is unresectable because of expansion over the mediastinum.⁴ For successful resection the perfusion of the affected lung should be over 33%, and pneumonectomy is necessary when perfusion of the affected lung is 34% - 40% from the total (12).

Wernly J.A. et al. (14) establish that quantitative perfusion scintigraphy is a necessary method to predict the post-operative function and its accuracy is not increased by the ventilation examination. Decreased perfusion in the involved lung should not be considered a contraindication to resection.

Svanberg L. (13) found that the decrease in regional lung function caused by cancer was closely related to the involvement of the regional lymph glands and hence to operability and five-year survival.

Ali M.K. et al. (1) study the loss of regional pulmonary function by ventilation and perfusion scintigraphy and examination of the breathing 1 and 3 months after the operation of lung carcinoma and postulate correlation coefficients of predicted and the actual post-operatively loss of pulmonary function in dependence with the number of resected segments. With increase of the resection increases the loss of function. After pneumonectomy correlation coefficient of predicted and actual loss of pulmonary function is between 0,81 and 0,91. The relative stability of pulmonary function after pneumonectomy is another fortunate situation.

Wu M-T et al. (17) compare prediction of post-operative pulmonary function in carcinoma of the lung between CT and lung perfusion scintigraphy. The quantitative CT has predicted post-operative FEV₁ after pneumonectomy in 28 patients $r=0,88$, and perfusion - $r=0,86$ ($p<0,001$). They recommend lung perfusion scintigraphy and other tests to be applied when the predicted FEV₁ is 40% or less. Ohno Y. et al. (9) compare perfusion magnetic-resonance tomography with lung perfusion scintigraphy in carcinoma of the lungs pre- and post-operatively together with

functional tests and they acquire for magnetic-resonance tomography $r = 0,93$, and for lung perfusion scintigraphy $r = 0,89$ with $p<0,001$. They consider that magnetic-resonance tomography is possible alternative of the lung perfusion scintigraphy to predict the post-operative pulmonary function in patients with lung carcinoma.

In our patients two of them are with higher perfusion rate in the interval (34% - 40%) and 2 presented with lower perfusion. In all of the cases the operation is successful. Two of the patients have perfusion of 11,7% and 12% and all of them had successful operation. The low perfusion indices of the affected lung could not be separately a contraindication for operative treatment and should be handled as a part of complex methods in pre-operative staging and determination of resectability of the patients. In our study two of the patients had survival under 1 year (8 and 10 months), two of them had survival under 2 years (14 and 16 months), one has survived 2 years and 8 months and one patient survived 5 years and 10 months, for the rest of them we don't have data about survival. The patient who has survived over 5 years the perfusion of the affected lung has been 50,9%.

CONCLUSION

Lung perfusion scintigraphy is a valuable method in the complex of pre-operative examinations to define the size of the defects of pulmonary perfusion and to predict the post-operative pulmonary function when pneumonectomy would be performed. The rate of the perfusion changes and the percentage of involvement of affected lung in common pulmonary function correlate with survival. Low perfusion of affected lung is not necessarily contraindication for operative treatment.

REFERENCE

1. Ali M.K., Mountain C.F., Ewer M.S., et al. Predicting Loss of Pulmonary Function After Pulmonary Resection for Bronchogenic Carcinoma. *Chest* 1980; 77: 3: 337-342.
2. Beckles M.A., Spiro S.G., Colice G.L. et al. The Physiologic Evaluation of Patients With Lung Being Considered for Resectional Surgery. *Chest* 2003; 123; 1: 106S-114S.

3. Datta D., Lahiri B. Preoperative Evaluation of Patients Undergoing Lung Resection Surgery. *Chest* 2003; **123**:2096-2103.
4. Ellis D.A., Hawkins T., Gibson G.J., Nariman S. Role of lung scanning in assessing the respectability of bronchial carcinoma. *Thorax*. 1983; **38**: 261-266.
5. Fletcher J.W., James A.E., Holman B.L. Regional Lung Function in Cancer. *Progr. Nucl. Med.* 1973, vol.3, 135-148.
6. Kim J-K., Jang S.H., Lee J.W. et al. Clinical parameters affecting prediction accuracy of postoperative lung function in non-small cell lung cancer. *Intract. Cardio.Vask. Thorac. Surg.* 2008; **7**: 1019-1023.
7. Levcheva V., Mluchkov M., Angelov V., Dzhambazov V., Cherveniyakov A., Potential of perfusion scintigraphy to determine the volume of pathologic processes in the lungs. Symposium – Modern diagnostic and therapeutic methods in pneumology. Varna 16-17.10.1987, Abstr. p.16. (in Bulgarian)
8. Mountain CF. A New International Staging System for Lung Cancer. *Chest* 1986; **89**: 225-33S.
9. Ohno Y., Hatabu H., Takenaka D. et al. Dynamic Perfusion MRI Versus Perfusion Scintigraphy : Prediction of Postoperative Lung Function in Patients with Lung Cancer. *AJR* 2004; **182**: 73-78.
10. Olsen G.N., Block A.J., Tobias J.A. Prediction of Postpneumonectomy Pulmonary Function Using Quantitative Macroaggregate Lung Scanning. *Chest* 1974; **66**: 13-16.
11. Secker-Walker R.H., Alderson P.O., Wilhelm J. et al. Ventilation-Perfusion Scanning in Carcinoma of the Bronchus. *Chest* 1974; **65**: 660-663.
12. Secker-Walker R.H., Provan J.L. Scintillation Scanning of Lungs in Preoperative Assessment of Carcinoma of Bronchus. *Br. Med. J.*, 1969, **3**, 327-330.
13. Svanberg.L. Regional Functional Decrease in Bronchial Carcinoma. *Ann. Thorac. Surg.* 1972: **13**: 170-180.
14. Wernly J.A., DeMeester T.R, Kirchner P.T. et al. Clinical value of quantitative ventilation-perfusion lung scans in the surgical management of bronhogenic carcinoma. *J. Thorac Cardiovasc Surg* 1980; **80**: 535-543.
15. Win T., Tasker A.D., Groves A.M. et al. Ventilation-Perfusion Scintigraphy to Predict Postoperative Pulmonary Function in Lung Cancer Patients Undergoing Pneumonectomy. *AJR* 2006: **187**: 1260-1265.
16. Von Beyer-Enke S.A., Clorius J., Becker H. et al. Synopsis von Computertomographie, Szintigraphie und Bronhoskopie bei der Diagnostik des Bronchialkarzinoms. *RöFo*, 1988; **149**: 121-238
17. Wu M-T., Pan H-B., Chiang A.A. et al. Prediction of Postoperative Lung Function in Patients with Lung Cancer: Comparison of Quantitative CT with Perfusion Scintigraphy. *AJR*; 2002; **178**: 667-672.