CLINICAL STUDY

Resection of multiple lung metastases – where are the limits?

Pereszlenyi A, Rolle A, Koch R, Schilling A, Baier B, Bis B

Department of Thoracic and Vascular Surgery, Fachkrankenhaus Coswig (Centre for Pneumology, Thoracic and Vascular Surgery), Coswig, Germany. **Pereszlenyi@fachkrankenhaus-coswig.de**

Abstract

Multiple lung metastases present a serious and challenging problem with increasing incidence for thoracic surgeons. In the lung metastasis management a significant role belongs to laser lung-parenchyma-saving resection. This parenchyma saving technique allows a removal of significant higher number of lung nodules in comparison to conventional techniques (stapler, clamp resection). Performing the lung metastasectomy by this manner, the only remaining question is the limitation of this technique.
In this retrospective study, the results after Nd:YAG Laser (1318 nm, 40 Watt) interventions are being presented, the limitations of this technique are being discussed *(Tab. 3, Fig. 4, Ref. 9)*.
Key words: lung metastasis, laser resection, limitation of laser metastasectomy.

Nowadays, the pulmonary metastasectomy presents a fully established accepted surgical therapy for selected patients suffering from a variety of malignant diseases (1, 2). In properly selected cases the procedure can be performed with a low morbidity and mortality rate (2, 3). Lung metastasectomy is routinely performed in many thoracic centers worldwide, however, only in few selected centers the procedure has been systematically applied for multiple or bilateral lesions (1). The technical feasibility, number of nodules, lung-parenchyma saving device – seems to be the most limiting factors to expand the scope of pulmonary metastasectomies and to make them more routinely utilized.

Objective of this paper is to review our experience with management of multiple lung metastases together with presentation of a new 1318 nm Nd: YAG laser system. Its lung-parenchyma saving attributes and so its feasibility for multiple bilateral metastases resection goes together with its limitation. This and more will be presented in following.

Description of the new 1318 nm laser system

Lung tissue with 80 % water content, very low tissue density and high shrinking capacity due to air content demonstrate tissue determinants very well feasible for photo thermal laser resection. The cornerstone to gain benefit for all types of parenchymal lung resection was to add adequate laser parameter (4, 5).

The second, 1318 nm wavelength of the new Nd: YAG laser significantly differs from the standard 1064 nm wavelength by its ten times higher absorption in water, however, it still offers sufficient laser light scatter, due its proximity to the beginning infrared spectrum, to satisfy the vital coagulation requirement as well.

This 1318 nm wavelength provides in fact the intended combination effect – cutting capability plus coagulation capability – as perfectly as could not be achieved with the 1064 nm wavelength (4, 5). As a welcome side-effect, there is strong lung tissue shrinkage providing two additional advantages: mechanical reinforcement of the coagulation effect, and fistula sealing far into the central lobe region. In fact, the surfaces coagulated and sealed off through defocused irradiation with the 1318 nm laser withstand artificial ventilation pressures of up to 25 cmH_20. Obviously, this beats all known haemostyptics and tissue glues several times over.

The average efficiency of a primary 1064 nm Nd:YAG laser is approximately 3 %. The energy efficiency of the 1318 nm emis-

Department of Thoracic and Vascular Surgery, Fachkrankenhaus Coswig (Centre for Pneumology, Thoracic and Vascular Surgery), Coswig, Germany, and Department of Informatics, Carl Gustav Carus University Dresden, Germany

Address for correspondence: A. Pereszlenyi, MD, PhD, Dept of Thoracic and Vascular Surgery, Coswig Specialized Hospital (Fachkrankenhaus Coswig), Centre for Pneumology, Thoracic and Vascular Surgery, Academic Teaching Hospital of Dresden University, Neucoswiger Str. 21, Coswig/ Dresden, 01640 Germany.
Phone: +49.3523.65314, Fax: +49.3523.65103

Annotation. The results after laser metastasectomy together with the limitation of this technique are presented in this retrospective study.

Fig. 1. Components of modern Laser equipment for the application on lung tissue (1318 nm wavelength, 40 W power output, beam quality, energy efficiency, high performance smoke evacuation system, 0.4 mm diameter of fibre, focusing handpiece, flexible quartz fibres /low water content/).

sion wavelength is only 34 % that of the primary 1064 nm wavelength. In order to achieve sufficient laser output power at 1318 nm, for lung parenchymal dissection, the system's efficiency must be increased to 5 % (4–6).

The following design features were incorporated to develop a 1318 nm commercial design Trumph (formerly Hüttinger Medizintechnik, Umkirch, Germany) and Martin companies (Fig. 1). The second wavelength is first generated by adapted reflection of the laser mirrors. High beam quality allows coupling into thin (less than 0.6 mm) optical quartz fibers with minimum losses. For flexible transmission to the area of application, special water-free quartz fibers are required as laser light absorption in water is 10 times higher at the 1318-nm wavelength (7, 8). A four-lens focusing hand piece was developed to concentrate the laser light and allow manual manipulation of the beam onto lung tissue to keep the working-point focus in the tissue at 4 mm while avoiding heat generation in the focusing hand piece. The extremely high laser power density of 24 kW/cm^2 allows fast and precise cutting with simultaneous coagulation and sealing of lung tissue. A high performance smoke evacuation system eliminates the vaporization fumes which are unavoidable during parenchyma dissection with this laser (9) (Fig. 1).

Summarized; there are three outstanding qualities of laser light for interaction with target lung tissue: coherence, collimation and monochromasy. In our laser system by a 1318 nm wavelength the unique specific laser-radiation quality was achieved.

Patients and methods

Demographics

In our Institute (Coswig Specialized Hospital (Fachkrankenhaus Coswig), Centre for Pneumology, Thoracic and Vascular Surgery) 328 patients underwent lung metastasectomy during the period between January 1996 and December 2003.

There were 164 males and 164 females in the age range from 20 to 80 yr (mean 61 yr). In all patients lung-parenchyma-saving resection by a new 1318-nm wavelength Nd:YAG laser was performed. The main indications for laser lung-parenchyma-saving resection included lung metastases of following primaries: renal carcinoma in 112 cases, colorectal in 91 and breast cancer in 35 cases. In the remaining 90 cases laser resection was performed for metastases of sarcomas (n=15), gynecologic malignancies (n=13), bronchogenic carcinoma (n=12), malignant melanoma (n=11), head and neck carcinoma (n=12) and for metastases of other less frequent ones (n=27) (Tab. 1).

The overall number of removed metastases was 2546 (7.8 per patient, ranged 1 to 124) (Tab. 2).

Tab. 1. Distribution of primary cancers in our series.

Site	No of pts %
kidney	112
colorectal	91
breast	35
sarcoma	15
gynecology	13
bronchogenic	12
melanoma	11
head/neck	12
other	27
Total	328

Tab. 2. Patient's features; Our data compared to International Registry of Lung Metastases/IRLM (1).

	IRLM n=5206	Coswig n=328	
Age (year, mean, range)	44 (2–93)	61 (20–80)	
Sex			
– male	56 %	50 %	
– female	44 %	50 %	
Complete	88 %	85 %	
Incomplete	12 %	15 %	
Deceased lymph nodes	5 %	19 %	
Approach			
– unilateral thoracotomy	60 %	54 %	
– bilateral thoracotomy	11 %	46 %	
– sternotomy	27 %	–	
– VATS	2 %	–	
Resection			
– Wedge	67 %	76 %	Precision laser 5 mm
– Segment	9 %	17 %	laser
– Lobe	21 %	7 %	
– Pneumonectomy	3 %	–	
		Number of nodules 3267, 10/Pat Number of met 2546, 7,8/Pat	

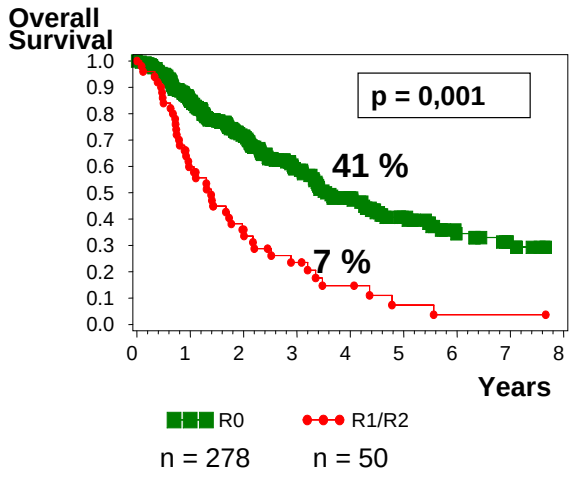

Fig. 2. Kaplan-Meier curve showing survival according to resection: Complete/ Incomplete (Squares = R0, Bullets = R1/R2).

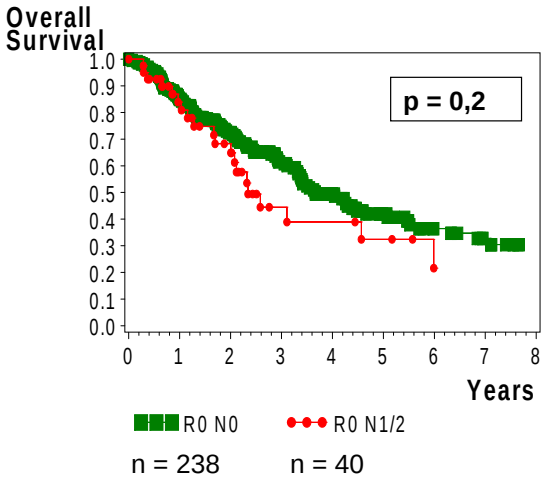

Fig. 3. Kaplan-Meier curve showing survival according to resection with or without lymph node involvement (Squares = R0/N0, Bullets = R0/N1,N2).

Surgical technique

Laser metastasectomy is performed via anterolateral thoracotomy (staged 3 to 4 weeks, if bilateral) after fulfilling the standard indication criteria for pulmonary metastasectomy (histologically confirmed primary tumor after its radical resection or its fully controlled stage). Preoperative evaluations are the same as for routine thoracic intervention; including history physical examination, chest computed tomography (CT), pulmonary function tests, and bone scan. If signs or symptoms are suggestive, head CT is also obtained. Patients with identified extrapulmonary metastasis are excluded from surgery (9).

Nevertheless, we expanded the further criteria for laser metasectomy recently. We included any primary malignancy with synchron and bilateral metastases. No limit to number of metastases was given but assessment of thoracic surgeon experienced in this laser technique was mandatory. Lymph node involvement up to unilateral N2 disease evaluated by rigid staging bronchoscopy and CT scan was included as well as previous extended chemotherapy.

All parenchymal resections were exclusively performed by 1318 nm laser, no hemostyptics, bioadhesives or staplers were used. Precision laser resection was done with 5 mm tumor margin, each nodule underwent pathological examination. Systematic lymph node resection was obligatory.

Results

Our results were compared to those of International Registry of Lung Metastases (IRLM) (1) and underwent multivariate analysis.

From the total of 328 patients; 278 (85 %) had a complete resection (R0), and 50 patients (15 %) an incomplete (R1 or R2) resection. In 14 % of R0 resection cases (n=40) were the lymph nodes tumor-positive (R0,N1 in six, and R0,N2 in thirty-four patients). In the remaining 238 cases (86 %) were lymphatic nodes free from metastases (R0,N0).

In 278 patients to whom the radical R0 resection was performed the recurrence rate was 60 %.

There was no perioperative mortality. Postoperative complications included prolonged air-leak in 2 and intrathoracic (intraparenchymal) bleeding in further 2 cases. All these complications were successfully overcome by conservative manners, without necessity of rethoracotomy. Follow-up was completed for all patients and it ranged from 1 to 198 Mo (mean 31).

Survival

In following the survival according to complete/incomplete resection, together with affected/non-affected lymph nodes is being presented.

Figure 2 shows the results after complete resection (R0) together with the results after the incomplete (R1/2) one. The difference is statistically highly significant (p=0.001).

Figure 3 presents the results after complete resection with (R0/N1,N2) and without (R0/N0) lymph node involvement. It can be seen from the graph they are of no statistical significance.

Tab. 3. Survival according to number of removed metastases (Compared to IRLM (1)).

Number of metastases	IRLM		Coswig	
	% 5y survival		% 5y survival	
1	47	43	28	55
2–3	27	34	23	33
4+	26	27	49	36
10+	9	26	21	28
20+	3	–	9	26

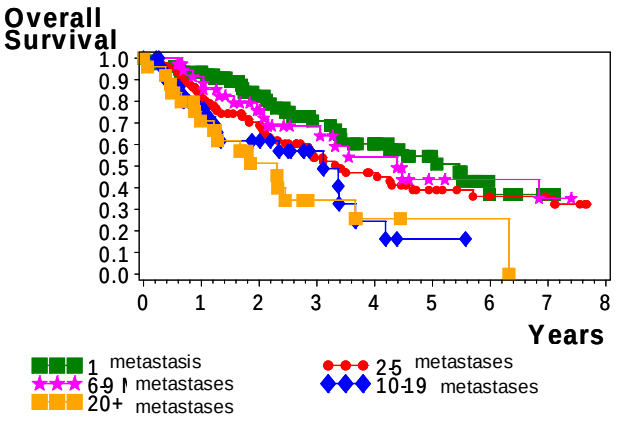

Fig. 4. Influence of the number of metastasis on survival (Dark squares = 1 metastasis, bullets = 2 to 5 metastases, stars = 6 to 9 metastases, diamonds = 10 to 19 metastases, light squares = 20 and more metastases).

As it was already stated above (Tab. 2), the results of this retrospective study were compared to those ones from the International Registry of Lung Metastases (IRLM) (1). In accordance to it the Figure 4 and Table 3 showing the survival dependent on the number of removed metastases.

Discussion

As it is shown from the results the most important prognostic factor is the complete resection. Only an instrument like our laser system that improves parenchyma saving resection of any nodule palpable in the lung facilitates complete resection and allows including higher numbers of metastases. In our retrospective study the 5 year survival was 41 % for patients after complete resection with a mean of 8 metastases resected per patient; and was poor, only 7 % after incomplete resection despite chemo- and chemo-radiotherapy. Figure 2. From the next graph (Fig. 3) it can be seen that in case of R0 resection the lymph node involvement doesn't play significant role in patient's survival. There is no significance of poorer outcome in case of complete resection.

There is a widespread acceptance that the number of metastases is another important prognostic factor (1, 2). If complete resection is considered survival curves show no real cut off point up to a number of 20 and more. The curve for 6–9 metastases is nearly identical to the one with solitary metastasis. That means that the prognostic significance of the number of metastasis is diminished and therefore allows recruiting patients with higher number of metastases for the surgery if the R0 resection can be expected.

In the Figure 4 (and Table 3) the 5-year survival rates for different number of metastases with complete resection are being presented. Half of the patients of the IRLM had solitary metastasis with 43 % 5-year survival. In our study a smaller amount of 28 % solitary metastasis with 55 % 5-year survival are presented. Half of those patients had 4 and more metastases with 36 % 5-year survival. 21 % of them had 10 metastases and more with a 5-year survival of 28 %. 9 % of our patients after the complete laser resection of 20 and more metastases have 3-fold higher survival (26 %) than those from the IRLM.

From the all above mentioned the role of new 1318 nm laser system in lung parenchyma saving surgery is proven. The new 1318 nm laser system improves any kind of parenchymal resection, facilitates resection of multiple bilateral and centrally located metastases and thus is lobe-sparing. Due to long term results criteria of eligibility should be aggressively expanded to higher number of metastases. Any palpable nodule in the deflated lung up to 1mm of size has to be resected because complete resection is the most important prognostic factor. As it was proven in our study, long term survival can be achieved for patients with 20 and more lung metastases and even for patients with N2 metastases. As it follows from the above mentioned; the number of metastases, their location (central, bilateral) do not present a limitation for the laser resection. The real limitations are same as for the resections for other malignancies in thoracic surgery: miliary spread or pleural carcinosis. Therefore, after keeping the indications criteria for lung metastasectomy (see in Chapter "Surgical Procedure") the lung laser resection of multiple metastases is reasonable and worthwhile, with the survival rate as it is presented above.

References

1. Pastorino U, Buyse M, Friedel G, Ginsberg RJ, Girard P, Goldstraw P, Johnston M, McCormack P, Pass H, Putnam Jr JB. Long-term results of lung metastasectomy: prognostic analyses based on 5206 cases. The International Registry of Lung Metastases J Thorac Cardiovasc Surg 1997; 113: 37—49.

2. Rolle A, Koch R, Alpard SK, Zwischenberger JB. Lobe-sparing resection of multiple pulmonary metastases with a new 1318 nm Nd:YAG Laser — First 100 patients. Ann Thorac Surg 2002; 74: 865—869.

3. Venn GE, Sarin S, Goldstraw P. Survival following pulmonary metastasectomy. Europ J Cardiothorac Surg 1989; 3: 105—109.

4. Rolle A, Unsöld E, Ruprecht L, Permanetter W, Frank F. Morphologic aspects of Nd:YAG laser application (wavelengths 1064 nm and 1318 nm) on lung tissue. Laser Med Surg 1988; 4: 10—14.

5. Rolle A, Thetter O, Häussinger K, Hallfeldt KKJ, Schmölder A. Einsatz des Neodym YAG Lasers in der Thoraxchirurgie. Herz Gefäss Thorax Chir 1989; 3: 85—91.

6. Rolle A. Laser applications in lung parenchyma surgery. Med Laser Appl 2003; 18: 271—280.

7. Bayly IG, Kartha VB, Stevens WH. The absorption spectra of liquid phase H_2O, HDO, and D_20 from 0.7 micron to 10 micron. Infrared Physics 1963; 3: 211—223.

8. Bramson M. Infrared Radiation. A handbook for applications. Plenum Press, New York, 1968.

9. Rolle A, Pereszlenyi A. Laser resection of lung metastasis. Multimedia Manual of Cardiothoracic Surgery 2005; in press.

Received June 30, 2005.
Accepted July 26, 2005.