KLS Martin Nd:YAG-Laser MY 40 1.3
UNIQUE EXPERTISE IN
PULMONARY PARENCHYMA SURGERY
Cancer – the word still has a devastating ring for patients when first confronted with the diagnosis. While it is true that great progress has been made in the treatment of cancer in the past decades, there is still the risk of a metastatic spread once the disease is under control or has been totally eliminated by appropriate therapies – particularly in the liver, lung or brain. The problem is that these organs consist of parenchymal tissue and therefore are difficult to treat surgically. Prof. Dr. Axel Rolle, of the Coswig/Dresden Specialized Hospital, has been working on these issues for many years and with outstanding success in the treatment of lung metastases. The advantage of his method is that only the affected metastatic tissue is actually removed with the laser, whereas conventional techniques require the excision of entire lung segments.

Introduction

The therapeutic use of heat to achieve hemostasis, coagulation or wound disinfection has a long history, belonging in fact to the world’s oldest surgical techniques.

Even back in ancient Egypt and Greece, hot oil was used for these purposes apart from incense and myrrh. Later on and until the late Middle Ages, doctors used cauteries for stopping the blood flow when performing amputations. After the invention of electricity towards the end of the 19th century, the first diathermy apparatuses soon came into use in the early 20th century. Then, in 1960, Th. MAI-MANN added a totally new and fascinating technology to the existing range of methods based on the ancient principle of thermotherapy – the ruby laser. For the first time, photothermal irradiation became a surgical option.

Although MINTON first demonstrated the successful vaporization of metastases in rabbits back in 1967 using a prototype of the Nd:YAG laser, it took another twenty years for this type of laser to be introduced into open thoracic surgery. At that time, most research teams relied on the 1,064-nm laser, simply because this was the standard wavelength used in endobronchial laser surgery, which already represented an established clinical procedure.

However, this standard wavelength has a crucial disadvantage resulting from its poor coagulation capability, attributable to a strong scattering effect. This means that hemorrhages increasingly occur in the deeper regions of the parenchymal tissue, starting at a depth of approx. 2 cm. Inevitably, hemostasis must then be achieved with conventional methods, i.e. using clips or sutures. This is unfortunate because it eliminates the very advantage of photothermal parenchyma resection.

Around the same time, I discovered the significance of the 1,318-nm wavelength for thoracic surgery. Following comprehensive experimental and clinical research conducted at the University of Munich, I could soon demonstrate that, due to its tenfold higher absorption coefficient in water, this wavelength offers significantly better cutting, coagulating and sealing properties than any other wavelength when applied to lung parenchyma. However, the development and implementation of appropriate laser equipment proved difficult at first, with the technical problems caused mainly by the Nd:YAG laser’s low efficiency at this wavelength.

As the laser equipment featured here shows, the initial drawbacks and problems have long been overcome. With its weight of 73 kg and external dimensions of 80 x 40 cm, the MY 40 1.3 Nd:YAG laser has in fact been miniaturized to an extent that allows easy handling and transportation. The quartz fibers and focusing handpiece have been specially adapted to the 1,318-nm wavelength to keep the...
heat build-up reliably under control and prevent fiber destruction. By using 400-µm fibers, power densities of 15 kW per cm² can be achieved in continuous mode, which enables fast vaporization and simultaneous coagulation of parenchymal lung tissue. After more than 300 laser interventions and subsequent evaluation, we could demonstrate that this surgical technique has a substantial parenchyma-sparing and lobe-preserving effect when treating multiple metastases, as evidenced by the significantly lower lobectomy rate. Moreover, this method can be used, with very few complications, for limited (such as segmental or bisegmental) resections in patients having primary bronchial carcinomas that cannot be treated with standard lobectomy. Further applications include the transection of extended parenchymal bridges and the coagulation and sealing of parenchymal fistulas and defects. In these cases, cost-efficiency is clearly an additional benefit because the MY 40 1.3 laser treatment significantly reduces the need for stapler magazines and costly glues otherwise required for fistula closing.

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Case 1:

Laser resection of a centrally located metastasis

Fig. 1a: Sketch of the lower lobe with the metastasis located right in the center, in a place where the lobe is thickest.

Fig. 1b: Preparing the resection, using the laser to expose the central metastasis. The middle and index fingers support the deflated lung, holding the tumor towards the dissecting laser beam. Thanks to the absence of hemorrhages, the surgeon has an excellent view of the surgical field.

Fig. 1c: The central tumor is clearly visible and easily accessible. It can now be cut out by hemorrhage-free “precision resection”, ensuring a safety margin of approx. 1 cm all-around.

Fig. 1d: Here is the final result. The metastasis has been removed and the lower lobe reinflated. The underwater test demonstrates the absence of fistulas and air leaks. The result is a completely expanded lower lobe. The only lung tissue lost is that of the dissection canal and the tumor itself (incl. the safety margin).
Case 2:

Lobe-sparing laser resection of difficult-to-access multiple metastases located in one lobe

This case shows the resection of altogether six metastases of a chondrosarcoma located in the shoulder of a 44-year-old male patient. The metastases have a size of 2–3 cm and are all sited in the left upper lobe, either peripherally, centrally or adjacent to the hilum. All metastases were removed with the laser, leaving the function of the upper lobe nonetheless fully intact.

Fig. 2a: Resection of the first peripheral metastasis having a diameter of 2.5 cm. Another metastasis, 3 cm large and located centrally near the hilum, can already be seen underneath.

Fig. 2b: Another metastasis (2 cm large), located next to the hilum and adjacent to the pericardium, is being removed with the laser.

Fig. 2c: Another metastasis with a diameter of 3 cm, located in the center of the upper lobe. As can be seen from the continuous suture of the visceral pleura, a metastasis has already been removed in the upper right corner.

Fig. 2d: Result after laser resection of six metastases. You can see the various adaptation sutures of the visceral pleura that reconstruct the surface of the left upper lobe. Thus, both the shape and the function of the upper lobe can be preserved.
Case 3: Laser resection of a large metastasis extending to the trunk of the lower lobe artery

Fig. 3a: CT image of a 44-year-old female patient with a 6-cm metastasis in the left lower lobe, contiguous to the pericardium.

Fig. 3b: Intraoperative findings: You can see the large metastasis contiguous to the pericardium but not infiltrating it. In the left middle section, the trunk of the pulmonary artery of the lower lobe is visible, being in immediate contact with the tumor. In such advanced cases, the standard conventional treatment option would be lobectomy.

Fig. 3c: Laser resection of this large metastasis located immediately next to the pulmonary artery. The tumor is being held aside in the lower section of the photograph. In the center of the picture, you can see a Vicryl thread leading to the segmental-artery and segmental-bronchus suture that can also be recognized.

Fig. 3d: Laser resection surface following removal of the metastasis. The entire surface is completely hemorrhage-free. The resection was performed on the completely deflated lower lobe, as still indicated by its dark appearance.
Fig. 3e: Re-adaptation of the lower lobe by a continuous suture of the visceral pleura. Note again the main artery of the lower lobe, visible in the lower left corner.

Fig. 3f: Condition after intraoperative re-inflation of the lower lobe. As can be seen, re-inflation is complete despite extensive parenchyma resection.

Fig. 3g: The resected metastasis, 6 cm in diameter, as a preparation. It was removed by way of a so-called “precision resection” with a safety margin of 1 cm, which is considered oncologically sufficient for metastases.

Fig. 3h: The final x-ray, taken shortly before the patient was sent home. The anteroaxillary thoracotomy performed on both lungs removed a total of 10 metastases, ranging between 2 and 6 cm in size. Both lungs are completely expanded. 18 months later, there are still no signs of a recurrence. Lung function is 102% of the age-adjusted standard value.
The Biophysical Foundations of the MY 40 1.3 Laser

Absorption spectrum of water

Laser parameters and tissue determinants

Fig. 4: Simplified schematic of the absorption spectrum of water (acc. to BAYLY et al.). Note the 1,064-nm and 1,318-nm wavelengths of the Nd:YAG laser which have been specially added.

As can be seen, there is a sudden tenfold increase in absorption at 1,318 nm, which accounts for the superior coagulation and cutting properties of this wavelength.

Fig. 5: This schematic shows important laser parameters and tissue determinants. You can see a laser beam with a focus of 600 µm set in relation to the anatomical parameters of lung parenchyma. Crucial tissue determinants are the low density of the lung tissue (0.15 g/cm³), its high water content (80%) and its high shrinking capacity that is due to the air content of the alveoli.

Fig. 6: A series of irradiation craters in lung tissue. The wavelength-specific differences are macroscopically visible. The upper row shows three craters caused by irradiation with the 1,064-nm laser at 30 W for 1 s. Two zones can be distinguished: The vaporization crater in the center, and a surrounding hyperemic zone of small hemorrhages. The crater itself also exhibits small hemorrhages. Lower row: Craters after irradiation with a 1,318-nm laser at 15 W (= half power) for 1 s. Three zones can be distinguished here: The vaporization crater in the center, then a wide, whitish coagulation zone surrounding it, finally a hyperemic margin.

Fig. 7: Individual irradiation crater created by a 1,318-nm Nd:YAG laser at 20 W/1 s. This magnified picture clearly shows the three-zone structure (as explained in Fig. 6).
All Advantages at a Glance:

Clinical advantages for metastatic surgery:

- A large number of metastases (>150) can be removed, ranging in size from a rice grain to a tennis ball
- Deep-seated metastases and tumors can be exposed and resected while preserving the affected segment or lobe
- Flexible, yet mechanically strong coagulation zones allow for surgical suturing of the visceral pleura as an additional safety measure
- Dry (hemorrhage-free) and fistula-tight resection surfaces
- Intervention can be repeated if recurrences occur
- Significantly higher life expectancy with almost no loss of quality of life

Economic advantages:

- Savings in expensive consumables (e.g. stapler magazines, fibrin glues)
- Extended interdisciplinary indications in open thoracic surgery, thoracoscopy and endobronchial surgery, therefore more patients can be treated
- The MY 40 1.3 enables the inclusion of patients that were previously considered “inoperable”
- Enhanced hospital reputation due to use of innovative laser technology and advanced methods

Application examples for open thoracic surgery:

- **Metastatic surgery**
  - Parenchymal bridge transection
  - Pulmonary vesicle resection
  - Open pulmonary biopsies
  - Removal of benign tumors
  - Bronchial carcinoma operations
  - Surgical techniques available: Enucleation, wedge resection, lobectomy, typical and atypical segmental resections, bisegmentectomy (plus a combination of any of these procedures)

Application examples for thoracoscopic surgery (VATS):

- Pulmonary vesicle ablation and thermal pleurectomies in cases of spontaneous pneumothorax
- Air vesicle ablation in pulmonary emphysema cases
- General hemostasis and fistula sealing
- Removal and enucleation of pleuropulmonary coin lesions (malignant and benign tumors)
- Partial resection of lung tissue
- Recurring pneumothorax
- Adhesiolysis
- Pleurodesis (various causes)

Application examples for endobronchial surgery:

- Tumor ablation
- Stenosis removal
- Vaporization of pathologic tissue
- Hemostasis
The KLS Martin MY 40 1.3 Laser Makes it Possible:

Effective cutting, vaporization, coagulation and sealing on a non-contact basis and without any need to exchange instruments. To make use of different focal distances, you simply need to exchange the front lens.

Thanks to the high-transmitting laser fibers and one of the best laser focusing handpieces available on the market, extremely high power densities can be achieved in the focus of the beam.

Features of the KLS Martin Focusing Handpiece for MY 40 1.3 Nd:YAG Lasers

To make the Nd:YAG laser light available for surgical use, we developed a top-notch optical system based on high-quality materials. This achieves exceptionally high power densities in the beam focus when using the handpiece in conjunction with a KLS Martin Nd:YAG laser and the 400-µm fiber. When applied to physiological tissue, this system impresses by its outstanding “non-contact” cutting, vaporization and coagulation properties.

The gas flow on the handpiece and along the fiber has been optimized as well. This ensures excellent gas irrigation efficiency unrivaled in this product class. The gas flow keeps the beam path free from absorbing particles (such as smoke/plume and tissue debris) between the focusing handpiece and the tissue. This also reliably prevents focusing lens contamination.

Two focal distances – 30 mm and 50 mm – are available to users. Along with the different front sleeves, this permits optimal adaptation of the system to the surgical task at hand. Thanks to the modular design of the handpiece, changing the focal length is a matter of seconds – you simply exchange the front lens. In addition, different front sleeves allow you to use different working distances.

As the beam profile shows, power density is extremely uniform across the entire surface of the beam focus.

The well-thought-out service concept – notably the quick-action connector that permits easy connection of the fiber to the handpiece, plus the easily exchangeable front lens – optimizes the availability of this instrument in daily clinical use – especially as any such exchange can be conveniently performed by the user him/herself whenever the need arises during operations.

<table>
<thead>
<tr>
<th>Laser fiber Ø (µm)</th>
<th>Focusing handpiece focal length (mm)</th>
<th>Power density kW/cm² Focus Ø (µm)</th>
<th>Laser power (W)</th>
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In conjunction with the MY 40 1.3 laser unit, the KLS Martin MY GAS 2 gas flow controller ensures constant and controllable irrigation gas consumption during laser application.

The gas flow is controlled via the two-stage laser foot switch. Both the working gas flow and the base gas flow can be set independently.

The underside of the MY GAS 2 gas flow controller features a magnetic foil that keeps it securely in place and prevents it from slipping off the laser unit.