Pulmonary resections: cytostructural effects of different-wavelength lasers versus electrocautery

Paolo Scanagatta1, Giuseppe Pelosi2, Francesco Leo3, Simone Furia1, Leonardo Duranti1, Alessandra Fabbri2, Aldo Manfrini3, Antonello Villa4, Barbara Vergani4, and Ugo Pastorino1

1Division of Thoracic Surgery, and 2Division of Pathology and Laboratory Medicine and University of Milan, School of Medicine, Milan; 3Division of Radioprotection, Fondazione IRCCS National Cancer Institute, Milan; 4Consorzio MIA (Microscopy Image Analysis), Monza, and University “Bicocca” of Milan, Italy

ABSTRACT

Aims and background. There are few papers on the cytostructural effects of surgical instruments used during pulmonary resections. The aim of the present study was to evaluate the parenchymal damage caused by different surgical instruments: a new generation electrosurgical scalpel and two different-wavelength lasers.

Methods. Six surgical procedures of pulmonary resection for nodules were performed using a new generation electrosurgical scalpel, a 1318 nm neodymium (Nd:YAG) laser or a 2010 nm thulium laser (two procedures for each instrument). Specimens were analyzed using optical microscopy and sansion electronic microscopy.

Results. Severe cytostructural damage was found to be present in an average of 1.25 mm in depth from the cutting surface in the patients treated using electrosurgical cautery. The depth of this zone dropped to less than 1 mm in patients treated by laser, being as small as 0.2 mm using the laser with a 2010 nm-wavelength and 0.6 mm with the 1318 nm-wavelength laser.

Discussion. These preliminary findings support the use of laser to perform conservative pulmonary resections (i.e., metastasectomies), since it is more likely to avoid damage to surrounding structures. Controlled randomized trials are needed to support the clinical usefulness and feasibility of new types of lasers for pulmonary resections.

Introduction

Although laser was introduced in 1985 to perform pulmonary resections in clinical practice1,2, only a few studies have tried to evaluate its cytostructural effects on pulmonary parenchyma compared to those caused by electrosurgical scalpel, or using lasers of different wavelengths3. In 1987, Cole and Wolfe4 published their experimental study, which demonstrated the mechanisms of healing of the injured lung treated with the neodymium-YAG (Nd:YAG) laser; the lasered lung appeared to heal like the cauterized lung, but with less fibrous reaction.

Since the late eighties, Rolle et al.2,3 have used an Nd:YAG laser with a wavelength of 1318 nm to perform pulmonary metastasectomies through precision resections, achieving a relevant experience in this field.

The aim of our study was to evaluate the parenchymal damage caused by different surgical instruments: a new generation electrosurgical scalpel and two lasers with different wavelengths (a 1318 nm Nd:YAG laser and a 2010 nm thulium laser).

Material and methods

After patient consent, during 6 surgical procedures of pulmonary resection of nodules performed using a new generation electrosurgical scalpel, a 1318 nm laser or a

Key words: devices, histology, lasers, lung, metastases/metastasectomy.

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Correspondence to: Paolo Scanagatta, MD, Fondazione IRCCS Istituto Nazionale dei Tumori, SC Chirurgia Toracica, Via G. Venezian 1, 20133 Milan, Italy. Tel +39-02-2390-2384; fax +39-02-2390-2907; e-mail paolo.scanagatta@istitutotumori.mi.it, paoscan@hotmail.com

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2010 nm laser (two procedures for each type of instrument), specimens of the cauterized or lasered surface of normal pulmonary parenchyma were biopsied and analyzed using optical microscopy (sections cut and stained with hematoxylin and eosin). The acute burn damage was identified and measured (median of at least five sections for each patient), according to the criteria identified by Cole and Wolfe.4

Two further specimens (a tangential section and a cross section) of the cutting surface of normal pulmonary parenchyma, measuring 5 x 5 x 2 mm, were collected and examined using scansion electronic microscopy (SEM) in order to determine morphologic structural alterations caused by the different devices. Characteristics of the damage and depth of the alteration were considered in order to determine the different effect of each instrument.

Results

Severe cytostructural damage was found to be present in an average of 1.25 mm in depth from the cutting surface in the patients treated using the electrocautery scalpel. The cutting surface appeared to be deeply altered, with cavities, coagulative disruption of the alveolar architecture and fusion of the different cell components, clearly visible with optical microscopy and better evidenced using SEM (Figure 1, panels A-B), with reproducibility and stability of these findings in specimens of different patients. This first zone consists in debris from the burn. The depth of this kind of alteration dropped to under 1 mm in patients treated by laser, being as small as 0.2 mm in the laser with a wavelength of 2010 nm and 0.6 mm in the 1318 nm laser.

The different devices used, with the measured depth of damage for each of the 6 patients according to the different devices, are summarized in Table 1.

A second zone of lung damage was represented by coagulated lung tissue, which was immediately underlying the first zone: this kind of alteration was better evidenced using conventional microscopy because the alveolar architecture was grossly respected and could appear normal using SEM.

The microscopic differences between electrosurgical scalpel and laser specimens are shown in Figure 1, panels A-D (SEM) and panels E-F (hematoxylin and eosin stained).

Discussion

In our opinion and according to IDEAL recommendations, the introduction in clinical practice of new devices should be evaluated using both experimental and clinical criteria. Therefore, even if the surgical use of lasers in order to perform pulmonary resections dates back to 1985, the validation of changes in new instruments, such as the introduction of new wavelengths, should be performed after considering the effects of these variations in microscopic behavior before entering any possible clinical application.

In 1987, Cole and Wolfe4 studied the effects of laser and electrocautery on pulmonary parenchyma of dogs and the mechanisms of healing at different times from surgery. They distinguished acute tissue damage of cautery or laser in two zones, the first one (zone 1) consisting of debris from burning, the second one (zone 2) of coagulated lung tissue immediately underneath. Their study demonstrated that this second type of alteration is partially reversible and that laser caused less fibrous reaction than cautery in the healing process.

Lasers with different wavelengths have different absorption lengths, which determines the depth of tissue penetration, neatness and rapidity of cutting, hemostasis and aerostatic power.2,3 As stated by Rolle et al.,2 the ideal laser for pulmonary resections should guarantee a good hemostatic capability and a precise cutting, thus reducing the risk of prolonged air leaks. Accordingly, they developed a Nd:YAG 1318 nm-wavelength laser, which demonstrated to be safe and efficient in the clinical practice through the years.

According to the results of our study, using this kind of laser, the acute tissue damage (zone 1) was limited to 0.6 mm (600 µm) in depth; zone 1 + 2 was about 1.1 mm (1100 µm).

Until today, the thulium 2010 nm-wavelength laser has been used only in urologic (prostatic) surgery and in neurosurgery, with overall good clinical results.6,7 The absorption length of this type of laser (0.18 mm, 180 µm) could be theoretically useful also in pulmonary surgery, and this microscopic and ultrastructural study seems to support the use of the device (the depth of zone 1 alteration was about 0.2 mm, 200 µm; zone 1 + 2 about 0.6 mm, 600 µm).

In accordance with the findings of Cole and Wolfe,6 our results confirm that the use of electrosurgical scalps, even newly developed devices, causes severe cytostructural damage when performing pulmonary resections (up to 2 mm from the cutting surface). Such findings are clearly depicted in Figure 1 and Table 1.

The preliminary impression, to be confirmed with further studies, is that the thulium laser allows faster resections than the Nd:YAG laser. In fact, the Nd:YAG laser seems to have more hemostatic power than thulium, but the advantage appears to be overwhelmed by the 2010 nm-laser preservation of surrounding tissues, which allows recognition of pulmonary vessels before cutting them.

A clinical trial on the use of the thulium 2010 nm laser to perform pulmonary resections is currently in progress to elucidate all these issues.

In conclusion, the electrosurgical scalpel caused severe damage in pulmonary ultrastructure. Laser instru-
Figure 1 - Scansion electronic microscopy showing cytostructural damage to lung tissue caused by the 2010 nm laser (on the left) or electrosurgical scalpel (on the right). Tangential sections (400x) are shown on panels A and B, and cross sections (50x) on panels C and D. Optical microscopic appearance of lung tissue treated by the 2010 nm laser (on the left) and electrosurgical cautery (on the right) is shown on panels E and F (hematoxylin-eosin, 4x). In panel F there is no normal lung visible.
ments preserved the pulmonary tissue better, even with a wavelength of 2010 nm. Such findings support the use of laser to perform conservative pulmonary resections (i.e., metastasectomies), since it is easier to avoid damage to surrounding structures. Controlled randomized trials are needed to support the clinical usefulness and feasibility of new types of lasers for pulmonary resections or other applications (anatomical resections).

References