Lung sealing using the tissue-welding technology in spontaneous pneumothorax§,§§

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Abstract

Objective: Welding of lung tissue is a new radio-frequency surgical method that allows sealing pulmonary tissue without overheating and damaging the tissue. The objective of the research was to study the results of sealing the lung tissue in a non-resectional procedure for spontaneous pneumothorax comprising ablation of bullae via video-assisted thoracoscopic surgery (VATS).

Methods: We present a series of 133 consecutive patients with primary spontaneous pneumothorax, who were operated on during the past 3 years. Among 133 patients, 123 were men and 10 were women, with an average age of 26 years (from 14 to 59 years). Indications for surgery were pneumothorax recurrence (59 patients), contralateral occurrence (13), bilateral pneumothorax (one) and haemopneumothorax (two). Prolonged air leakage for more than 2 days was observed in 58 patients. We used the tissue-welding technology and an original bipolar hand-piece for bullae electroablation and lung sealing. Conventional apical pleural abrasion was carried out in all cases. Chest tubes were removed 48 h postoperatively by protocol.

Results: Intraoperatively, emphysema-like changes and blebs under 1 cm were seen in 29 patients (22%) and bullae of 1—2 cm in 48 patients (36%); in 56 cases (42%) the size of bullae exceeded 2 cm. In all cases, lung sealing was achieved by tissue welding alone, without using staplers, sutures, glues and sealants. The operating time depended on the presence of adhesions and the number of bullae, but did not exceed 65 min. Postoperative air leakage for 1—6 days was observed in six patients. Neither mortality nor major morbidity was observed. There were seven recurrences (5.2%).

Conclusions: The tissue-welding procedure is easy to perform through VATS and is efficient for ablation of bullae of any size. Leak-proof sealing is achieved, allowing us to repair the pulmonary—pleural fistula, thus being a non-resectional alternative to wedge resection. No conventional wound-closing devices are needed.

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Keywords: Spontaneous pneumothorax; Lung sealing; Welding

1. Introduction

There are several recent publications dedicated to the use of electrosurgical coagulation methods in procedures on pulmonary tissue and spontaneous pneumothorax [1—3]. Our interest in such studies originates from the search for a reliable alternative to the use of metal staples during wedge resection procedures and improvement of non-resectional treatment methods for spontaneous pneumothorax.

This report describes our experience in the use of a new radio-frequency (RF) system for the welding of bullae and sealing the pulmonary—pleural fistula in spontaneous pneumothorax. This new system uses a special live tissue welding (LTW) generator that produces bipolar RF energy. This energy is controlled by an automatic microprocessor, which controls the welding current parameters depending on high-speed sampling of the tissue being welded and adherence to a unique and patented algorithm. The advantages of this technology are no tissue overheating (operating temperature does not exceed 65 °C), minimal necrosis and damage to pulmonary tissue and the fact that the area of LTW is confined to the area of the electrodes.

The objective of this study was to evaluate a new non-resectional method for video-assisted thoracoscopic surgery (VATS) in spontaneous pneumothorax.

2. Materials and methods

A total of 553 patients with spontaneous pneumothorax were hospitalised at our clinic during the past 3 years. Direct (medical) thoracoscopy was done under local anaesthesia in all the patients with diagnosed pneumothorax to examine the lung and pleural cavity. Each thoracoscopy concluded with a...
5- to 6-mm diameter pleural drainage. After the lung expanded, which was established by clinical signs, a computed tomography (CT) of the thorax was performed in all the patients. Based on the clinical, thoracoscopy and CT data, 56 patients with secondary pneumothorax were excluded from the study.

Among 497 patients with primary spontaneous pneumothorax 133 needed surgical treatment; of these 123 of them were men, 10 were women, and the average age was 26 years (ranging from 14 to 59 years). A left-side procedure was done in 52 cases, a right-side procedure in 80 cases and a bilateral procedure in one case. Indications for surgery were pneumothorax recurrence (in 59 patients), contralateral occurrence (13), bilateral pneumothorax (one) and haemopneumothorax (two). Prolonged air leakage for more than 2 days was observed in 58 patients. All 133 consecutive patients were operated on via conventional three-port VATS under general anaesthesia with endotracheal intubation.

We used the LTW system (the generator and linear hand-piece) for the sealing/welding of bullae and the lung surface (approved by the State Department for Supervision of Quality and Safety in Medications and Medical Devices, Certificate of State Registration No. 3383/2004).

The welding process uses a bipolar electrode to compress the bullae and emphysematous pulmonary tissue; the collapsed wall of a bulla is intimately fused to the underlying pulmonary tissue and acquires a whitish colour (Video 1). The design of the welding software algorithm eliminates any concerns regarding overheating or carbonisation or burning through. In cases of an obvious air leakage source, the bullae and pulmonary tissues were sealed by tissue welding immediately around this source. In cases where there was no obvious pulmonary—pleural fistula, all visible emphysema-like changes were treated with the LTW system. Prolene mesh apical abrasion up to the 7th rib level was done in all the cases. Two chest tubes, with an outer diameter of 6 mm, were introduced after the end of each procedure.

In all the cases, the chest tubes were removed when no more air diffused and effusion was under 150 ml per day; the chest tubes were not removed prior to 48 h postoperatively. The patients were discharged after radiologic control 24—48 h after the check-up.

3. Results

Intra-operatively, emphysema-like changes and blebs under 1.0 cm in diameter were seen in 29 patients, solitary or multiple bullae 1.0—2.0 cm in diameter in 48 patients, and in 56 patients the diameter of bullae exceeded 2 cm. In all cases, ablation of the bullae and lung sealing was achieved by welding only, without the use of any mechanical metal staplers, sutures or sealants. Operating time depended on the presence of adhesions, on the number of bullae and their extension over the lung's surface. The average operating time was 50 min (ranging from 20 to 65 min).

Postoperative air leakage for 1—6 days was observed in six patients; no additional treatment was used in all these cases. There was no need for conversion to thoracotomy in any of the patients. There were no mortality and no major morbidity. There were seven cases of recurrence (5.3%) during the follow-up time of 2—37 months. All patients with recurrence of pneumothorax have undergone axillary thoracotomy and conventional wedge lung resection.

4. Discussion

The LTW technology for repair of tissues and organs is smokeless, with little heat migration in the tissue, results in no necrosis (Fig. 1) and does not use foreign matter or conventional wound-closing devices, such as staples, sutures, glue or sealants. Not requiring staples appears to be a potential source of cost saving. Surgical manipulations are very easy and convenient to perform; they do not require any special skills of the surgeon.

The procedures are almost bloodless while sealing damaged tissue aimed at restoring the normal functions of the lung.

Prospects of the electrosurgical method which allows coagulation and connection of tissues without overheating and 'burning through', while having a feed back from the tissue being welded, appear encouraging. Numerous animal studies and certain cases when CT was performed after welding of the lung surface show that the depth of the welding thermal effect on the lung parenchyma does not exceed 3 mm while providing reliable sealing. Using the LTW system through VATS for treatment of even 'difficult' bullae, located over the mediastinal surface of the lung or in the interlobar fissure, is exceptionally convenient. The welding technique allows avoiding the use of conventional endo-staplers with acceptable level of postoperative recurrences. We do not perform spirometry routinely in patients who have primary spontaneous pneumothorax, and in certain cases at the beginning of the study, we did not observe any deterioration in spirometry indices after the use of tissue welding. The causes of postoperative recurrences are not sufficiently established. In view of the relatively short follow-up time, it needs to be assumed that the real recurrence rate might be higher. While our preliminary results are encouraging, efficiency of the tissue-welding application for secondary pneumothorax is not sufficiently studied because of its heterogeneity. The use of welding technology for non-

Fig. 1. Histological view of the welded area and underlying hyperaemia.
Resectional lung volume reduction surgery (LVRS) requires further experimental research.

5. Conclusions

The tissue-welding procedure is easy to perform through VATS and is efficient in the ablation of bullae of any size, thus being a non-resectional alternative to the wedge resection.

Leak-proof sealing of the pulmonary—pleural fistulae can be done using welding current, excluding the use of staples, sutures or sealants.

This new welding technology produces results equal to or better than those typically obtained by institutions using conventional mechanical staples and wedge resection procedures for spontaneous pneumothorax.

References


Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.ejcts.2009.11.017.