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Original Article / Özgün Makale

Video-assisted thoracoscopic laser ablation in the treatment of primary spontaneous pneumothorax

Primer spontan pnömotoraks tedavisinde video yardımlı torakoskopik lazer ablasyon

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Background: This study aims to investigate the feasibility of the video-assisted thoracoscopic (VAT) laser ablation technique in the treatment of primary spontaneous pneumothorax (PSP).

Methods: Between January 2006 and June 2012, 60 patients with complicated PSP were included. Patients were prospectively randomized into two groups including 30 patients in each. Video-assisted thoracoscopic blebectomy and/or bullectomy with staplers was performed for group 1, whereas VAT laser ablation was performed for group 2. Pleural abrasion using the Marlex mesh was performed in both groups. A single chest tube (28 F) per patient was inserted. The operating time, number of complications, duration of hospital stay, duration of tube thoracostomy, and PSP recurrence rate were compared between the groups.

Results: The median stapler use was 1.6 (1-4) in group 1, and the median energy use was 2700 J (1800-3700 J) in group 2. The median operating time was 31 min (17-65 min) in group 1 and 34 min (15-59 min) in group 2. Delayed lung expansion occurred in only two patient (6%) in group 1 and 22 patients (75%) in group 2 ($p \leq 0.05$). The mean hospital stay was 2.75 (2-4) days in group 1 and 3.7 (2-10) days in group 2 ($p \leq 0.05$). The duration of chest tube use was 2.3 (1-7) days in group 1 and 7.9 (2-14) days in group 2 ($p < 0.001$). There was two PSP recurrence (5%) in group 1 and one lung collapse following chest tube removal in group 2.

Conclusion: Although delayed lung expansion due to thermal damage may develop, VAT laser ablation appears to be safe and effective with comparable results to those of VATS bullectomy.

Keywords: Bullectomy; laser; primary spontaneous pneumothorax; video-assisted thoracic surgery.

Amaç: Bu çalışmada video yardımlı torakoskopik (VAT) lazer ablasyon tekniğinin primer spontan pnömotoraks (PSP) tedavisinde uygulanabilirliği araştırıldı.

Çalışma planı: Ocak 2006 - Haziran 2012 tarihleri arasında komplike PSP olan 60 hasta çalışmaya alındı. Hastalar prospektif olarak her biri 30 hastadan oluşan iki gruba randomize edildi. Grup 1'deki hastalara VAT ile stapler kullanılarak blebektomi veya büllektomi yapılır iken grup 2'deki hastalara VAT ile laser ablasyon yapıldı. Plevral abrazyon her iki gruptaki hastalara Marleks yama kullanılarak yapıldı. Tüm hastalara tek bir toraks dreni (28 F) konuldu. İki grubun ameliyat süresi, komplikasyon sayısı, hastanede yatış süresi, tüp torakostomi süresi ve PSP nüks oranları karşılaştırıldı.

Bulgular: Grup 1'de medyan stapler kullanımı 1.6 (1-4) iken, grup 2'de medyan enerji kullanımı 2700 J (1800-3700 J) idi. Grup 1'de medyan ameliyat zamanı 31 dk. (17-65 dk.), grup 2'de 34 dk. (15-59 dk.) idi. Gecikmiş akciğer ekspansiyonu grup 1'de sadece iki hastada (%6), grup 2'de 22 hastada (%75) ($p \leq 0.05$) görüldü. Ortalama hastanede yatış süresi grup 1'de 2.75 (2-4) gün, grup 2'de 3.7 (2-10) gün idi ($p \leq 0.05$). Toraks tüpünün kalış süresi grup 1'de 2.3 (1-7) gün, grup 2'de ise 7.9 (2-14) gün idi ($p < 0.001$). Grup 1'de iki hastada (%5) PSP nüksü görülürken, grup 2'de bir hastada toraks tüpü çekimi sonrası akciğer kollapsı görüldü.

Sonuç: Isıl hasar nedeniyle gecikmiş akciğer ekspansiyonu görülebilmesine karşın, VAT laser ablasyon tedavisinin, VATS büllektomi ile karşılaştırılabilir sonuçları ile güvenilir ve etkili olduğu söylenebilir.

Anahtar sözcükler: Büllektomi; lazer; primer spontan pnömotoraks; video yardımlı toraks cerrahisi.

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A pneumothorax is an accumulation of free air between the lung and the chest wall. This term was first introduced in 1803 by Itard, who was a student of Laennec, and Laennec later described the clinical picture of a pneumothorax in 1819.[1] Despite the absence of underlying pulmonary disease in patients with a primary pneumothorax, subpleural blebs and bullae likely play a role in the pathogenesis of the disease since they are present in up to 90% of cases.[2]

There are two objectives in the surgical management of a pneumothorax. The first and most widely accepted objective is to treat the underlying defect by resecting the blebs or applying sutures to the apical perforation site. The second objective is to create pleural adhesions in order to prevent recurrences.[1] The advent of video-assisted thoracic surgery (VATS) has enabled surgeons to determine the most appropriate surgical intervention. It is also minimally invasive and is used more often than open thoracic surgery.[3] In addition to staple resection via videothoracoscopy, other techniques have also been used by researchers. In 1973, Takeno[4,5] used the laser ablation technique because of unsuccessful results with electrocautery resection. The purpose of this study was to determine the feasibility of the laser ablation technique in the treatment of a primary spontaneous pneumothorax (PSP) and compare the results with those of VATS resections for blebs and bullae.

PATIENTS AND METHODS

Following approval by the university ethics committee (2008-3/9), 60 patients who underwent PSP treatment between January 2006 and June 2012 were prospectively randomized into two groups by treatment technique. Group 1 was composed of 30 patients (3 males, 27 females; median age 25.5 years; range 16 to 42 years) who underwent a VATS blebectomy and/or a bullectomy with staplers, and group 2 was comprised of 30 patients (24 males, 6 females; median age 26.5 years; range 19 to 41 years) who underwent a VATS laser ablation technique to resect the bullae and/or blebs.

The exclusion criteria included patients with a secondary spontaneous pneumothorax diagnosed on computed tomography (CT), those who had previously undergone emergency or normal operation. Surgery was indicated for 35 patients (58%) with bilateral bullae diagnosed on CT, 11 patients with an ipsilateral recurrence of a PSP, six patients with contralateral recurrence of a PSP, and three patients for occupational reasons (Table 1).

All of the patients were operated on using the VATS technique, which was performed under general anesthesia in the operating room by the same thoracic team. A double-lumen endotracheal tube allowed adequate ventilation of the contralateral lung lobes while the ipsilateral lung lobes remained in atelectasis. The patients were placed in the lateral decubitus position according to the pneumothorax side.

In group 1, 45-60 mm (3.5-4.8) endostaplers (Covidien, Mansfield, MA, USA and Ethicon Endo-Surgery, Cincinnati, OH, USA) were used for the bullectomy and/or blebectomy. Furthermore, in all cases, apical pleural abrasion was performed using a piece of Marlex mesh (Ethicon Endo-Surgery, Cincinnati, OH, USA).

In group 2, a 980 nm, 150 W diode laser (Evade®, biolitec biomedical technology GmbH, Jena, Germany) with a reusable 'cool tip' fiber or a single-use 0.6-1 mm fiber with or without a 'smoke evacuator' was used in 25-30 W non-contact mode. Routine apical pleural abrasion was performed in all cases. At the end of the procedure, a 28-F chest tube was inserted through a camera port and placed at the apex of the pleural cavity. Next, it was connected to an underwater seal drainage system. All of the patients were extubated in the operating room and then transferred to a ward. Pain control was achieved with local anesthesia

Table 1. Surgical indications of the patients

	Group 1	Group 2		
	Staplers	Laser	*Total*	*p*
Bilateral bullae diagnosed on CT	17	18	35	NS
Ipsilateral recurrent pneumothorax	6	5	11	NS
Contralateral recurrent pneumothorax	3	3	6	NS
Persistent air leak	3	2	5	NS
Occupational reasons	1	2	3	NS
Total	30	30	60	

CT: Computed tomography; NS: Not significant.

Table 2. Preoperative and postoperative surgical characteristics of the patients

	Group 1 Stapler				Group 2 Laser				
	n	%	Median	Range	n	%	Median	Range	*p*
Median number of stapler cartridges			1.6	1-4			–	–	
Median time/energy			–				12 seconds/2700 J		
Median operating time (minutes)			31	17-65			34	15-59	NS
Heimlich valve	2	7			22	73			<0.001
Median chest tube drainage (days)			2.3	1-7			7.9	2-14	<0.001
Pleural space		7		2/30		73		22/30	<0.001

NS: Not significant.

(0.5% bupivacaine to all port sites) as well as intravenous patient controlled anesthesia (IV PCA). Air leakage of more than five days was accepted as being prolonged, and those patients with prolonged air leaks or a pleural space were discharged home with a Heimlich valve and monitored as outpatients for one week.

Statistical analysis

The operating times, number of complications, length of hospital stay, duration of chest tube usage, and disease recurrence rates were compared between the two groups, and variables were compared using chi-square tests, as appropriate. Statistical analysis was performed with the SPSS for Windows version 11.0 statistical software (SPSS Inc., Chicago, IL, USA).

RESULTS

The mean operation time was 31 minutes (range 17-65) in group 1 and 34 minutes (range 15-59) in group 2. In addition, the median amount of staplers used was 1.6 (1-4) in group 2, and the median laser usage time was 12.5 seconds (range 10-21). Furthermore, the amount of energy used in group 1 was 2700 (1800-3700) J. A pleural space exceeding 48 hours was observed in 22 patients in group 2 and two in group 1 (p<0.001) (Table 2). All 24 patients with a pleural space were discharged home with a Heimlich valve. The median chest tube drainage time was 2.3 days (range 1-7) in group 1 and 7.9 days (range 2-14) in group 2 (p<0.001). There was no in-hospital mortality.

Air leakage was observed in two patients (7%) in group 1, but none experienced this complication in group 2. The drains of the patients with prolonged air leakage were removed at the sixth and seventh days, respectively. The median hospital stay was 2.8 days (range 2-4) in group 1 and 3.7 days (range 2-10) in group 2, and the median follow-up was 2.5 years (range 1-3) in group 1 and 2.2 years (range 1-3) in group 2. Additionally, PSP recurrence was seen in only two patients in group 1 (Table 3).

DISCUSSION

A PSP is not associated with an underlying pulmonary disease, even if blebs and bullae play a role in its pathogenesis. It occurs in more than one in 100,000 women and more than seven in 100,000 men each year and affects adolescents at a higher rate than other sectors of the population.[6] The modern description of a PSP occurring in otherwise healthy people was provided by Kjaergard in 1932.[7]

After the first recurrence of a pneumothorax, the subsequent recurrence rate is very high (approximately 50% after a second episode and 80% after a third episode), making surgery mandatory.[8]

Table 3. Postoperative complications

	Group 1				Group 2				
	n	%	Median	Range	n	%	Median	Range	*p*
Air leakage		7		2/30		0			NS
Hospital stay (days)			2.75	2-4			3.7	2-10	NS
Follow-up time (years)	2.5				2.2				NS
Recurrence		7		2/30		0			NS
Success rate		93				100			NS

NS: Not significant.

Other indications of surgery are chest drainage failure in the first episode of PSP (persistent air leakage for more than five days with insufficient or no lung expansion), an ipsilateral or contralateral recurrent pneumothorax, bilateral bullae formation observed on CT, and factors related to lifestyle (time spent in remote areas or no easy access to emergency medical care) or occupation (divers and pilots).[9] In our report, surgery was indicated for 35 patients with at least one episode of PSP and bilateral bullae diagnosed on CT, 11 patients with ipsilateral recurrence of PSP, six patients with contralateral recurrence of PSP, and three patients for occupational reasons.

The aim of surgical treatment is to stop air leak and apply pleurodesis to reduce the rate of recurrence.[10] Today, many researchers approve of the techniques used with VATS (wedge resection and pleurectomy) because they provide excellent results and a very low percentage of relapse.[11] In addition, recent advances in VATS have changed the attitudes with respect to surgical intervention. Furthermore, compared with open surgical techniques, VATS offers superior results, decreased postoperative pain, shorter hospital stays, and decreased morbidity.[12] Several recent papers have noted decreased postoperative pain, shortened hospital stays, and early restoration of functional activity after the resection of blebs and pleurodesis using VATS.[13,14] Moreover, when the results of VATS were compared with those of conventional thoracotomies for the treatment of a recurrent spontaneous pneumothorax, the mean recurrence rate after VATS was higher and was very similar to that found after transaxillary minithoracotomies.[15,16] However, in experienced hands, VATS reduces the operation and pleural drainage time, postoperative complication rates, and length of hospital stay and allows the patient to rapidly return to performing normal daily activities.[6]

Other techniques, including lasers, have also been used in the treatment of a pneumothorax. In 1973, Takeno[4,5] used a thoracoscopic electrocauterization technique instead of bleb resection in patients with a spontaneous pneumothorax. Although, this technique is no longer used because of its 18.6% recurrence rate, this rate has been diminished to 2% with the use of the Nd:YAG laser ablation technique. In 1989, Hansen et al.[17] successfully treated 33 of 35 patients with a spontaneous pneumothorax using fibrin glue and had an acceptable recurrence rate of 9%. Although many minimally invasive techniques have been studied, the laser ablation technique is still considered to be the most viable alternative to the standard surgical operation.

The first clinical series of laser ablation was reported by Wakabayashi et al.[18] in 1991. In their study, carbon dioxide (CO_2) laser ablation via thoracoscopy was used for 22 patients with multiple bullae or diffuse emphysema. The most common postoperative complication was an expansion failure that resulted in death in two of the patients. The postoperative space spontaneously resolved on postoperative day 13 for the other patients in their study. In our clinic, we use laser therapy for endobronchial treatments, metastasectomies, and emphysema surgery. The most common problem in this study involved pleural space during the early postoperative period in group 2. However, we may have overestimated our results since all of the patients in the laser group with pleural space were discharged home with a Heimlich valve on the postoperative either second or third day. There might have been fewer incidents of patients with pleural space had they been kept in the hospital during their entire recovery period. No recurrence was observed in group 2.

Wakabayashi[19] also retrospectively reviewed 44 patients treated with Nd:YAG laser ablation and emphasized that thoracoscopic laser ablation is an effective treatment technique with acceptable risks. Hazama et al.[20] reported the cases of 120 PSP patients, 60 of whom underwent laser ablation surgery. They placed the patients with a PSP and a bleb smaller than 2 cm, as determined via high-definition CT, in the laser ablation group. Although the study was not prospectively randomized, there were no significant differences in terms of postoperative complications and surgical success between the staple and laser ablation groups. In 1994, Sharpe et al.[21] performed Nd:YAG laser ablation for 13 patients with a persistent pneumothorax and compared their results with those who underwent resection with poly-tetrafluoroethylene (PTFE)-reinforced staplers. Consistent with our study, they also concluded that laser ablation was an effective technique for treating a spontaneous pneumothorax but that this procedure had a relatively long lung expansion time (pleural space). However, the combined use of laser and staple surgery has been emphasised as a technique that provides long-term results in patients with emphysema.[21] Although, the laser ablation technique in our study resulted in a pleural space that persisted after 48 hours in 75% of the patients, treatment with a Heimlich valve was successful in all of our cases.

Many hypotheses have been proposed for the delayed expansion of lungs treated with lasers. When performing this procedure, there is a potential risk that laser ablation of the bullae and the surrounding

tissue may increase the possibility of bleeding or thermal damage to the tissue surrounding the bullae. Indeed, the YAG laser has hemostatic effects due to moderate abrasion; however, excessive abrasion induces pulmonary parenchyma injuries, causing severe alveolar bleeding and prolonged air leakage.[20] However, using the non-contact laser mode with a shorter application time, as we did in this series, eliminates the risk of thermal damage. The most widely accepted clinical series in this area was conducted by Sawabata et al.[22] in 1995. They examined the efficacy of laser treatment on the lung parenchyma of patients with malignant pathologies. In total, 216 samples were collected from 24 lung lobes, and the results were classified according to application techniques and outcomes. They divided the ablation techniques into non-contact, pointed contact, and rubbing contact groups, and the outcomes were categorized as either coagulative, morphologically degenerative, or destructive. During laser ablation, 5, 10, and 15 W energies were used for five seconds in the contact mode in their study, and 7.5, 15, and 30 W energies were used for 1.5 seconds in the non-contact mode. In the non-contact ablation group, coagulation and morphological degeneration was dependent on the energy level, and in the contact ablation group, morphological destruction occurred after the application of 10 W of energy. Moreover, it has been implied that expansion deficiency, which is commonly seen in laser studies, is related to pleural degeneration that results from the contraction of elastic fibers and degeneration of collagen fibers due to the photo thermal effect of the laser. Furthermore, Cole and Wolfe[23] reported extensive fibrosis and alveolar hyperemia as a result of parenchymal coagulation at the Nd:YAG laser ablation sites.

In conclusion, although the presence of pleural space, the need for a chest tube, or the application of a Heimlich valve for a more prolonged period of time was observed in group 2 as a result of thermal damage by the laser, we still believe that treating a PSP via a laser is effective and has comparable results to those of VATS bullectomies.

Declaration of conflicting interests

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