Results of Li-Tho trial: a prospective randomized study on effectiveness of LigaSure® in lung resections†

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Received 28 May 2013; received in revised form 26 July 2013; accepted 1 August 2013

Abstract

OBJECTIVE: The role of electro-thermal bipolar tissue sealing system (LigaSure®, (LS); Covidien, Inc., CO, USA) in thoracic surgery is still undefined. Reports of its use are still limited. The objective of the trial was to evaluate the cost and benefits of LS in major lung resection surgery.

METHODS: A randomized blinded study of a consecutive series of 100 patients undergoing lobectomy was undertaken. After muscle-sparing thoracotomy and classification of lung fissures according to Craig-Walker, patients with fissure Grade 2–4 were randomized to Stapler group or LS group fissure completion. Recorded parameters were analysed for differences in selected intraoperative and postoperative outcomes. Statistical analysis was performed with the bootstrap method. Pearson’s χ² test and Fisher’s exact test were used to calculate probability value for dichotomous variables comparison. Cost-benefit evaluation was performed using Pareto optimal analysis.

RESULTS: There were no significant differences between groups, regarding demographic and baseline characteristics. No patient was withdrawn from the study; no adverse effect was recorded. There was no mortality or major complications in both groups. There were no statistically significant differences as to operative time or morbidity between patients in the LS group compared with the Stapler group. In the LS group, there was a not statistically significant increase of postoperative air leaks in the first 24 postoperative hours, while a statistically significant increase of drainage amount was observed in the LS group. No statistically significant difference in hospital length of stay was observed. Overall, the LS group had a favourable multi-criteria analysis of cost/benefit ratio with a good ‘Pareto optimum’.

CONCLUSIONS: LS is a safe device for thoracic surgery and can be a valid alternative to Staplers. In this setting, LS allows functional lung tissue preservation. As to costs, LS seems equivalent to Staplers.

Keywords: Electro-thermal sealing • Lobectomy • Pareto optimum

INTRODUCTION

Lobectomy is the standard of care in most patients with early stage non-small-cell lung cancer (NSCLC). Nowadays, surgical staplers are widely used to complete fissures [1]. The electro-thermal bipolar tissue sealing system (LigaSure®, (LS); Covidien, Inc., CO, USA) was developed as an alternative to sutures, clips and other ligation methods. The system detects the type of tissue in the instrument jaws and delivers the appropriate amount of pressure and energy needed to transform the collagen and elastin within the vessel walls to seal them permanently (Fig. 1). A microprocessor-controlled radio-frequency current is used, and an audio signal from the generator advises the surgeon when the seal cycle is complete, with minimal lateral thermal damage. In contrast to bipolar diathermy, which depends on factors such as duration of application, surrounding fluid and repeat applications, the LS seals by means of alterations in tissue impedance. LS has been used extensively in general surgery and other disciplines especially to divide short gastric vessels, splenic artery, liver tissue and colonic vessels [2, 3]. Nevertheless, the role of the LS device in thoracic surgery is still undefined. Reports on experimental and clinical use in thoracic surgery for bullectomies and pulmonary wedge resections have been published in the medical literature [4–7]. We designed a randomized controlled study to compare staplers with LS for the completion of lung fissures and to evaluate the costs and benefits of LS.

MATERIALS AND METHODS

This randomized, controlled, parallel-group designed trial compares the techniques for completion of interlobar fissures with staplers or LS in a consecutive series of 138 patients, undergoing pulmonary lobectomy. Sample size was determined with the PASS Power analysis software (NCSS, Kaysville, UT, USA) using simulation; the study had a power of 0.85 to detect a 0.5-day difference of postoperative air leaks in median total hospitalization length of
stay, given a two-sided alpha of 0.05. All patients who were scheduled for elective pulmonary lobectomy were eligible for inclusion in the study. The hospital Ethics Committee approved this study. The purpose of the study was explained to all patients and informed consent was obtained. After muscle-sparing thoracotomy, the completeness of a fissure was evaluated and grouped into four stages, according to the Craig–Walker’s classification [8]: Grade 1—complete fissure with entirely separate lobes; Grade 2—complete visceral cleft but parenchymal fusion at the base of the fissure; Grade 3—visceral cleft evident for part of the fissure; Grade 4—complete fusion of the lobes with no evident fissural line. Patients with Grade 1 fissures \((n=38)\) were excluded from the study; therefore, only patients with Grade 2, 3 and 4 fissures \((n=100)\) were included in the Li-Tho trial. In addition, patients with gross invasion of the fissure requiring pneumonectomy were deemed ineligible. As a result, 100 consecutive patients were randomized into two groups of 50 patients each. Randomization was performed intraoperatively, by opening a sealed and signed numbered non-translucent envelope that contained the randomization code (allocated by a computer-generated random sequence) [RANDOM.ORG is a true random number service that generates randomness via atmospheric noise (www.random.org)]. The nature of the treatment precluded blinding the surgeons (Luca Bertolaccini and Alberto Terzi) who performed operations. In the Stapler group \((50\) patients\), staplers were used for completion of fissures; in the LS group \((50\) patients\), only LS was used, instead of staplers, for completion of fissures (Fig. 2). After completion of fissures with staplers or LS, parenchymal air leaks were evaluated by submergence of the resection site in saline solution and re-ventilation of the lung, applying a peak pressure of 25 submersion of the resection site in saline solution and sures with staplers or LS, parenchymal air leaks were evaluated by

**Figure 1:** Completion of a Grade 3 fissure with LS.

Figure 2: LS intraoperative utilization.

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sutured. Afterwards, in all patients, two chest drains were placed \((28\)-Fr tubular drain anterior and 24–Fr spiral drain [Redox srl, Poggio Rusco (MN), Italy] posterior\). The drains were connected to a Redox Simple Plus with Drentech Palm system (Redox srl) for continuous air leak measurement. All patients initially had their chest tube placed on −15 cm H₂O suction for 24 h after surgery. Air leaks were evaluated and data collected twice a day. The post-operative management of the patients in both groups was performed by two other skilled surgeons (Andrea Viti and Antonio Cavallo), without the knowledge of or reference to the treatment allocation. Chest drains were removed when <250 ml/day of fluid was drained and the air leaks completely resolved [10]. The estimated daily cost of hospitalization per patient was 800 Euros. For each patient assigned to the Stapler group, one DST Series—GIA (Covidien, Inc.) Single Use Reloadable Stapler \((80\ mm in length—4.8\ or 3.6\ mm thickness) with additional recharges as needed was used. The cost of each stapler was 180 Euros for the device with the first charge and 120 Euros for each additional recharge. In the LS group, the cost of each LS device was 434 Euros. All recorded parameters were analysed for differences in selected intraoperative and postoperative outcomes and for cost-benefit evaluation.

**Statistical analysis**

A CONSORT checklist was completed [11]. Statistical analysis was realized with the bootstrap method using 1000 simple bootstrap samples with 95% confidence interval. The two groups were compared by the unpaired t-test or Wilcoxon’s two-sample test applied to discrete or continuous data, and by the Pearson’s \(\chi^2\) test or Fisher’s exact test, when appropriate, applied to dichotomous or categorical data. Stratified analysis of categorical data was performed with the Cochran–Mantel–Haenszel procedure. The normality of data distribution was assessed by the Shapiro–Wilk test. The significance level was set to 0.05 for all efficacy and safety parameters. Cost-benefit evaluation was performed using Pareto optimal analysis. In game theory and economics, the concept of Pareto efficiency (or Pareto optimality) is a method to judge the efficiency of a set of decisions made by the participants [12]. Pareto diagrams could be applied in designing medical processes in order to identify errors, faults and incidents, or in the construction of a system that reduces the risk of medical care, and in
analysing performance data in health organizations [13]. Statistical and mathematical models were created and analysed using Wolfram Mathematica 8.0. [Wolfram Mathematica is a computational software program used in scientific, engineering and mathematical fields as well as other areas of technical computing (www.wolfram.com/mathematica).]

RESULTS

One hundred patients (59 males and 41 females; mean age 72.3 years, range 49–83) were included in the study and randomly assigned to each of the two groups (Fig. 3). The demographics and baseline characteristics of the patients are presented in Table 1; there wasn’t any stratification, minimization or block design for the groups. All patients underwent lobectomies and systematic lymph node dissection for NSCLC. The difference in fissure type, according to the Craig–Walker’s classification, was not statistically significant between the two groups. The distribution of air leaks in the LS group, according to Macchiarini’s scale, is presented in Table 2. There was no significant difference in the length of time required to perform the two techniques. On postoperative day 1, air leakage was detected in 28 (55%) patients in the LS group and 22 (45%) in the Stapler group. On postoperative day 2, air leakage was detected in 16 (31%) patients in the LS group and 14 (28%) in the Stapler group. There were no statistically significant differences between groups in volume of postoperative air leaks. No persistent air leakage (for >7 days) was detected in both groups (Table 3). The mean duration of air leaks was 5.0 days in the LS group, without statistically significant difference with the 4.3 days recorded in the Stapler group (P = 0.82). The cumulative persistence of air leaks in the two arms of the trial is shown in Fig. 4. For each patient, the cumulative and average fluid drainage during the observation period and the days with leaks were calculated, and the results did not show a statistically significant difference between procedures. In the LS group, the daily drainage amount was 580 ± 70 vs 470 ± 100 ml in the Stapler group (P = 0.00069). The LS group had drains in place for a mean time of 5.3 (range 4.0–8.5) days, whereas the mean time was 4.6 (range 3.5–6.7) days in the Stapler group; this difference (16.8 h) was not statistically significant (P = 0.83). There was no difference in the overall incidence of complications in the groups (P = 0.65); no adverse effects were observed intraoperatively or postoperatively regarding the use of LS; no perioperative mortality was observed; no patient

Table 1: Demographic characteristics and preoperative pulmonary function

<table>
<thead>
<tr>
<th>Patient characteristics</th>
<th>LS group (N = 50)</th>
<th>Stapler group (N = 50)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years, mean ± SD (range)</td>
<td>69 ± 4 (47–81)</td>
<td>68 ± 7 (49–71)</td>
<td>0.93</td>
</tr>
<tr>
<td>Past medical illness</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COPD</td>
<td>13</td>
<td>11</td>
<td>0.68</td>
</tr>
<tr>
<td>Diabetes</td>
<td>4</td>
<td>6</td>
<td>0.53</td>
</tr>
<tr>
<td>Smoking</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any history of smoking</td>
<td>23</td>
<td>21</td>
<td>0.76</td>
</tr>
<tr>
<td>Current smoker</td>
<td>27</td>
<td>29</td>
<td>0.79</td>
</tr>
<tr>
<td>Preoperative pulmonary function, mean ± SD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FEV1 (%)</td>
<td>77 ± 6.5</td>
<td>78 ± 9.8</td>
<td>0.45</td>
</tr>
<tr>
<td>FVC (%)</td>
<td>92 ± 4.1</td>
<td>86 ± 4.8</td>
<td>0.74</td>
</tr>
<tr>
<td>DLCO (%)</td>
<td>95 ± 6.2</td>
<td>99 ± 7.5</td>
<td>0.79</td>
</tr>
<tr>
<td>DLCO/VA (%)</td>
<td>79 ± 7.1</td>
<td>67 ± 6.2</td>
<td>0.96</td>
</tr>
</tbody>
</table>

COPD: chronic obstructive pulmonary disease; FEV1: forced expiratory volume in 1 second; FVC: forced vital capacity; DLCO: diffusing capacity of the lungs for carbon Monoxide; DLCO/VA: ratio of the DLCO to Alveolar Volume (measured as ventilatory volume).

Table 2: Surgical characteristics and parameters

<table>
<thead>
<tr>
<th>Patient characteristics</th>
<th>LS group (N = 50)</th>
<th>Stapler group (N = 50)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of surgical operation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lobectomy</td>
<td>50</td>
<td>50</td>
<td>NA</td>
</tr>
<tr>
<td>Pleural adhesion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>26</td>
<td>32</td>
<td>0.43</td>
</tr>
<tr>
<td>Minimal</td>
<td>12</td>
<td>10</td>
<td>0.67</td>
</tr>
<tr>
<td>Extensive</td>
<td>12</td>
<td>8</td>
<td>0.37</td>
</tr>
<tr>
<td>Fissure’s type (Craig–Walker’s classification)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>17</td>
<td>16</td>
<td>0.86</td>
</tr>
<tr>
<td>III</td>
<td>24</td>
<td>23</td>
<td>0.88</td>
</tr>
<tr>
<td>IV</td>
<td>9</td>
<td>13</td>
<td>0.39</td>
</tr>
<tr>
<td>Operating time [min], mean ± SD</td>
<td>75 ± 15</td>
<td>80 ± 10</td>
<td>0.28</td>
</tr>
<tr>
<td>Leakage (Macchiarini’s scale)*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade 0</td>
<td>3</td>
<td>15</td>
<td>0.0047</td>
</tr>
<tr>
<td>Grade 1</td>
<td>8</td>
<td>16</td>
<td>0.10</td>
</tr>
<tr>
<td>Grade 2</td>
<td>37</td>
<td>16</td>
<td>0.0060</td>
</tr>
<tr>
<td>Grade 3</td>
<td>2</td>
<td>3</td>
<td>0.65</td>
</tr>
</tbody>
</table>

NA: not applicable; min: minute.
*The leakage was measured before application of intraoperative standard techniques for air leak reduction.
required a reoperation. Three (3%) patients, 1 (2%) in the LS group and 2 (4%) in the Stapler group, experienced atrial fibrillation that necessitated pharmacological cardioversion. The difference in the mean hospitalization length of the two groups did not achieve statistical significance ($P = 0.88$). The mean cost of hospitalization, 5100.00 (range 4300.00–7200.00) Euros for the LS group and 4675.00 (range 3900.00–8100.00) Euros for the Stapler group, was $\approx 425$ Euros lower for the Stapler group ($P = 0.89$). The mean cost of the LS Group was not significantly different from that of the Stapler group (37 500.00 Euros for LS vs 23 280.00 Euros for Stapler; $P = 0.068$). All of the Pareto fronts produced in this study were convex, as predicted from their representation as approximations of the true Pareto fronts (Fig. 5). The LS group had a favourable multi-criteria analysis of cost/benefit ratio [14], with a good ‘Pareto optimum’. The concept of a Pareto front captures the intuitive notion of a ‘trade-off’ in optimization problems with multiple objectives, where the objective values measure different aspects of an element of the conformation space. In a typical setting, the objectives are partially or wholly in conflict. From these assumptions, the notion of an optimum solution cannot be defined without additional constraints. The approximation of elements is usually a computationally challenging task in continuous multi-objective optimization, and for large discrete conformation sets, the Pareto front is often of exponential size. We employed the notion of Pareto sets for the formal presentation of our trial and the display of variations in score values produced by different target prediction tools in the recurrent procedure. The follow-up of the patients in both groups (mean = 6 months) of the trial was uneventful.

DISCUSSIONS

The energy produced by the high-power ultrasonic dissection systems (55 kHz) is frictional energy, proportional to both the vibration frequency and the displacement of the instrument tips. These devices function because they generate heat from the mechanical friction between the tissue and the vibrating blade. Proteins begin to denature when the temperature reaches 60°C. When heat is delivered relatively gradually, and provided the temperature remains <100°C, proteins denature from the colloidal state into an insoluble gel, which is necessary for vessel coagulation. In addition, the ultrasound energy induces a cavitation effect in water-containing tissues, and this facilitates tissue separation. The only physical disadvantage is the ‘storm’ effect (dust cloud caused by non-viable tissue particles sprayed by the electronic shears), which becomes problematic only with close-up work [15]. The thermal energy frequently causes sticking of the sealed area to the jaws of the instrument. The sealed area can be released from the unharmed instrument with irrigation and careful manipulation. The thermal vessel sealers are also being used in tissues other than vessels. It has been used for ureteral division, bile duct ligation and intestinal closure. In a study [4], LS was used to seal pulmonary tissue, bronchi and vessels in pigs.
design enabled us to evaluate the efficacy and safety of LS in completion of lung fissures. The cost of LS is almost the same as GIA linear stapler with recharges, and it can be used for lymph node dissection in the same surgical session [16]. In the medical literature, it has been observed that the LS system significantly reduced the blood loss for an equivalent operating time compared with electrocautery [17]. In contrast to staplers, the LS system has a disadvantage in controlling air leakage from the incompletely sealed parenchyma. This trial was designed to compare two different fissure completion techniques during a major lung resection. The use of LS, the application of which is clearly different from that in previous studies, is only a part of the procedure that was carried out. Bootstrap analysis was proposed as a breakthrough method for internal validation of surgical regression models [18]. The main advantage of this technique is that the entire dataset can be used for model building, which would yield more robust models, especially in moderate size databases and for rare outcomes. Furthermore, the predictive validity of the model can be assessed not only in one randomly split set of patients, but also typically in 1000 new different samples of the same number of patients as the original database obtained by means of resampling with replacement. We observed a significantly greater incidence of air leaks in the LS group, with a spontaneous relevant reduction in the first postoperative 24 h; of interest is the fact that no patient had prolonged air leaks. The 74% of patients with Grade 2 air leaks after completion of fissures in the LS group is not a technical failure; it is related to the mechanism of sticking the parenchyma, according to the thickness of the lung tissue to seal. There were more postoperative leaks on the first day; nevertheless, they subsided very quickly for the inflammatory reaction produced by the high-energy devices that aided to seal the leaks. Furthermore, the thermal injury in the tissues may be the reason for the higher fluid output in the LS group. The resection of lung parenchyma using staplers leads to an excellent tissue sealing and haemostasis [19]; its disadvantages are that foreign bodies are left with possible interference in case of reoperation or during positron emission tomography/computed tomography scan re-evaluation. Moreover, stapler’s head size and length are sometimes difficult to use in certain operative situations. There are reports on the use of LS for pulmonary resection in experimental animal models [20] and subsequently, with good results, for pulmonary wedge resection, bullectomies and fissure dissection [4, 21]. Approved indication for vessel closure is up to 7 mm in diameter and for lung tissue it is up to 15 mm in thickness. Aside from small vessel sealing and fissure completion, the use of the LS technique improved the ablation of pleural adhesions and the haemostasis obtained in previous studies between the two groups of patients. Compared with staplers, LS allows a better tailoring of lung resection margins, thus saving functional lung tissue, and the pathological evaluation of the specimens obtained showed that the maximal depth of thermal damage was <2.4 mm. In the LS group, the ability of the regulated dissection to preserve as much pulmonary parenchyma as possible permits the residual lung a better expansion and a better capacity to fill the thoracic cavity, thus reducing the residual pleural space after lobectomy.

**CONCLUSIONS**

LS is safe and easy-to-use with a minimal rate of complications. Its head is smaller than the stapler’s head and it is a good handling device; therefore, it can facilitate approaching difficult situated areas. It does not leave any foreign body and produces safety tissue sealing and haemostasis, without deep tissue damage. The difference in the costs of the two groups of patients seemed to be due to the device (Stapler or LS) price alone. The results confirm the efficacy and safety of the haemostasis obtained in previous studies performed in other surgical specialties. LS can be a valid alternative to staplers for fissure completion in major lung resections.

**Conflict of interest:** none declared.

**REFERENCES**


[16] Lacin T, Fevzi Batirel H, Ozer K, Demirutku A, Ahiskali R, Yuksel M. Safety and efficacy of the haemostasis obtained in previous studies performed in other surgical specialties. LS can be a valid alternative to staplers for fissure completion in major lung resections.
and in the other margin. So we to 4, yes, it is correct, LigaSure is not a stapler. When we use LigaSure, if we LigaSure group and the cost of the stapler group for the number of patients, the burn the lung, and so the lung responds with an in air leak. We also noted a high volume of pleural single versus multiple days of intensive care unit stay for a patient in atrial

| APPENDIX. CONFERENCE DISCUSSION |

Dr K. Papagiannopoulos (Leeds, UK): I think there is a wealth of literature regarding the use of high energy devices, but obviously this is mainly not in thoracic surgery but in colorectal, urological and gynaecological surgery. One matter of caution is that although high energy devices work with a similar principle, I think the thermal injury that we see and the results that they have on tissue and tissue sealing are slightly different.

If we look at your study, your patients seemed to have fairly good lung function tests and they seemed to have, I guess, a good quality of lungs. If we look also at the grade of intraoperative air leaks, it becomes obvious that this was more in the LigaSure than in the stapling devices. Looking at your postoperative leaks, as you said, you had more on the first day but they subsided very quickly, and it might be, I guess, the inflammatory reaction produced by the high energy devices that eventually helped seal the leaks that you had; also thermal injury or the thermal changes that you had in the tissues might have produced more drainage.

I have a little bit of a problem with the calculations. You showed that your mean hospital cost was not very much different; it was a couple of hundred Euros between the two groups, but you said that your mean cost for the LigaSure was €37 500 while it was €23 000 for the staplers, and if I make the calculations for your consumables on the staplers, I come up with the same figure, but not for the Ligasure group. So I am not entirely sure where the difference comes on the LigaSure.

The questions are very simple. Do you recommend that high energy devices will be equally safe in any lung that we have, because we deal with elderly patients, patients with significant COPD and emphysema. Do you think that high energy devices are equally safe in any fissures, because they are obviously not the same on the right and left side in all lobes. Would you think that high energy devices would be more or less cost effective in VATS surgery, because all your patients have been done with open surgery, and I am not sure the applicability in VATS surgery is the same. And obviously the question I have is would different energy settings be necessary depending on the 3D configuration that we have on the fissure? So would we need in the future to consider having single versus multiple firings on the high energy devices?

Dr Bertolaccini: In the LigaSure group, we had 56% of patients smoking and 26% with COPD. In COPD patients, we observed an increased incidence of postoperative air leak, fortunately without having any patient with prolonged air leak. We also noted a high volume of pleural fluid effusion after surgery in the LigaSure group. So, according to the electrothermal sealing properties, we burn the lung, and so the lung responds with an inflammatory response.

About the cost, the difference in mean hospital length of stay was not statistically significant, but the difference in the overall costs was aggravated by two days of intensive care unit stay for a patient in atrial fibrillation with previous coronary artery disease. Nevertheless, if we divided the overall cost of the LigaSure group and the cost of the stapler group for the number of patients, the relative difference of cost is over €250 per patient in the Ligasure group.

Concerning the last question about the multiple firing for a fissure of type 3 or 4, yes, it is correct, LigaSure is not a stapler. When we use LigaSure, if we open the lung parenchyma, we use the Ligasure in the margin, in the middle, and in the other margin. So we ‘surf’ on the lung surface.

Dr P. De Leyn (Leuven, Belgium): Can I ask you, was the indication for the lobectomy? I assume it is not lung cancer, because all pulmonary functions were almost normal. I also have a question like Dr. Papagiannopoulos. If you have more grade 2 air leaks in patients with more severe emphysema and more COPD, I assume these air leaks would not seal off that quickly with LigaSure. What was the indication for the lobectomy, and you mentioned you had the same amount of COPD patients but pulmonary function was almost normal.

Dr Bertolaccini: Perhaps the study was afflicted by the 56% of current smokers and a lot of patients who were ex-smokers. And the number of COPD patients?

Dr De Leyn: Was the indication lung cancer?

Dr Bertolaccini: Yes, the indication was non-small cell lung cancer in the 100 patients.

Dr H. Hansen (Copenhagen, Denmark): I would like to pose a few technical questions. There are lots of devices out there, and you are using only a 10 mm LigaSure. Can it also be done with a 5 mm LigaSure sealing a lesser area? My second question is about the stapler; which type of stapler do you use? A new generation of stapler is out there, the Tri-Staple, with different heights and clips that might even improve results because the forces along the stapler line have changed. So which type of staplers did you use in the study?

Dr Bertolaccini: We used the LigaSure Impact device, and we used the DTS Series – GIA with the green stitches.

Dr M. B. Marshall (Washington, DC, USA): Given that all lobectomies aren’t created equal, I wondered if you looked at middle lobectomies, which are physiologically much more like a wedge excision, versus upper or lower lobectomies?

Dr Bertolaccini: We analysed the different types of lobectomy. We had a longer hospitalization in right lower lobectomy, because the incidence of the incomplete fissure between the middle and inferior lobe was increased. So we stratified the patients for the different types of lobectomy.

Dr Marshall: And they were equivalent between both groups?

Dr Bertolaccini: Yes.

Dr Marshall: And I just want to comment, I use the LigaSure on the pulmonary artery branches, the small ones. It works quite well. For the small vessels we have had no concerns about bleeding.

Dr O. Tiffet (St. Etienne, France): Two short questions, one about the design of the study. How did you calculate the number of patients; what are your primary evaluation criteria about the size, the number of patients? And the second thing is, I don’t think you close a patient with a drain fluid air leak, so there is certainly another cost involved in using seal, etcetera.

Dr Bertolaccini: The sample size was calculated according to Cochran. Our primary endpoint was the difference in air leakage. The sample size calculator determined a population size of 94, but we increased the groups to 100 patients. Could you repeat the second question?

Dr Tiffet: When you have a grade 3 air leak at the end of the procedure, I think you don’t close the patient, so there is an added cost using seal, for example.

Dr Bertolaccini: If there was a grade 3 air leak, I tried to correct the air leak with stitches, or LigaSure if the patient was in the LigaSure group.

Dr T. Rice (Cleveland, OH, USA): At first inspection this appears to be a negative study. My questions are, is this truly powered with 50 patients per arm to detect a difference? And, randomized studies are supposed to randomly assign patients, but in this small study the majority of your patients with the LigaSure had more complete fissures. So is it truly a negative study? Is it that people with LigaSure with more complete fissures do as well as people who are stapled with incomplete fissures?

Dr S. Celik (Istanbul, Turkey): Did you consider the thickness of incomplete fissure? That classification doesn’t stress the importance of fissure thickness. Is it possible to do it for 4 mm thickness?

Dr Bertolaccini: It is possible to do it, but we have to change a concept in our mind. LigaSure is not a GIA. So, I can’t cut and close the fissure. I have to open the fissure and use the LigaSure on the margin of the fissure, then on the middle, then on the other margin; I have to ‘surf’ on the lung parenchyma.

Dr Celik: Did you compare the LigaSure and stapling from the point of view of injury to surrounding tissues?

Dr Bertolaccini: Yes, but there are some papers in literature that stated that LigaSure is safe and the thermal wound depth is 1-1.5 mm from the branches.