A prospective randomized trial comparing completion technique of fissures for lobectomy: Stapler versus precision dissection and sealant

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Objective: Alveolar air leaks are common after pulmonary resection, often prolonging hospitalization and increasing surgical morbidity and costs. Air leakages result from lung tissue traumatized by the dissection of fissures. This randomized and controlled trial evaluates 2 different surgical techniques for the completion of interlobar fissures during pulmonary lobectomy to establish which is superior in preventing air leakage.

Methods: There were 20 patients in each of the 2 groups: Electrocautery was used for precision dissection and collagen patches were coated with human fibrinogen and thrombin (TachoSil, Nycomed, Vienna, Austria) for aerostasis in the electrocautery and sealant group (ES), and the approved routine surgical procedure with staplers was used in the stapler group (ST).

Results: Statistically significant reductions of air leakage were found in the ES group in the overall incidence of air leaks (50% vs 95%, $P = .0001$), duration of air leaks (1.7 days vs 4.5 days, $P = .003$), and procedure costs (425 euros vs 630.5 euros, $P = .0001$). There were no complications related to the use of the patches, and a significantly lower incidence of dead pleural space was observed in the ES group (5% vs 40%, $P = .020$).

Conclusion: The use of electrocautery dissection and collagen patches coated with human fibrinogen and thrombin (TachoSil, Nycomed, Vienna, Austria) for aerostasis to complete interlobar fissures seems to be safe and effective in reducing alveolar air leaks and procedure costs. Although this pilot study showed advantages in terms of hospitalization and cost benefits, further multicentric studies are required to clarify that these differences are statistically significant.

Pulmonary lobectomy, performed by the division of the parenchyma through scission of the fissures, remains the standard therapeutic option in most patients with early-stage non-small cell lung cancer. Persistent alveolar air leaks, the most common complication after major pulmonary resection with an incidence of 3% to 25%, occur more frequently when interlobar fissures are incomplete. Persistent alveolar air leaks have negative consequences on morbidity (empyema, deep vein thrombosis, and respiratory infections), culminating in increased hospitalization with negative economic effects and delays of adjuvant treatment.¹⁻¹⁰ Most air leaks result from dissection of the fissures as demonstrated by the intraoperative air leaks exhibited by the traumatized lung tissue. Surgical staplers are widely used to complete fissures, usually providing reliable hemostasis but without obtaining an airtight closure for parenchymal tears at lung reexpansion under ventilation.^{1,2}

We designed a randomized prospective controlled study to compare 2 different techniques to complete interlobar fissures during pulmonary lobectomy. Forty patients were enrolled and randomly assigned to 1 of the 2 procedures. In the electrocautery and sealant group (ES), electrocautery was used for precision dissection (a technique that was initially developed by Perelman¹¹), and a collagen patch coated

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Abbreviations and Acronyms

ES	= electrocautery and sealant group
ST	= stapler group
AAL	= alveolar air leak

with human fibrinogen and thrombin (TachoSil) was applied for aerostasis. In the stapler group (ST) approved routine surgical procedure with staplers was performed.

The trial was conducted according to the ethical principles of the Declaration of Helsinki and in accordance with local requirements and good clinical practice. This document was written according to the International Conference on Harmonisation E9 (Statistical Principles for Clinical Trials) and E3 (Structure and Content of Clinical Study Reports) guidelines of the European Agency for the Evaluation of Medicinal Products.

Materials and Methods**Study Objectives**

This randomized, prospective, controlled parallel-group designed trial compares 2 different techniques for completion of interlobar fissures during pulmonary lobectomy. The patients involved were assigned to 2 groups: the ES group (20 patients), in which electrocautery was used for precision dissection and a collagen patch was coated with human fibrinogen and thrombin (TachoSil) was applied for aerostasis, and the ST group (20 patients), in which an approved routine surgical procedure with staplers was carried out. This is a pilot study, and no attempts have been made to calculate a sample size to provide statistical power sufficient for confident evaluation of the result.

The first goal was to assess the percentage of demonstrated intraoperative alveolar air leak effectively sealed after application of the patch (TachoSil) in ES and to compare the proportion of patients in the experimental and control groups who were free of air leaks throughout hospitalization.

The second goal was to compare the experimental group with a control group in terms of the postoperative day that the last air leak was observed, the moment of chest tube removal, and the length of hospitalization. Other aspects that were analyzed were the costs of the procedure and hospitalization, and the safety of the experimental procedure in comparison with standard procedure by surveillance of the incidence and severity of complications.

Patient Selection

The study was performed at Carlo Poma Hospital, Mantova, Italy, during a period of 11 months (May of 2006 to April of 2007). Patients with early-stage non-small cell lung cancer who were scheduled for elective pulmonary lobectomy were eligible for inclusion in the study. The purpose of the study and potential risks and benefits of the procedure were explained to all patients, who were required to give signed informed consent before entering the trial.

During surgery, patients were deemed ineligible for further participation if the surgical treatment was completed by a video-assisted approach; if they underwent pneumonectomy, sleeve resection,

or bronchoplasty; if they had an inoperable disease; or if other sealant materials were used.

At thoracotomy, fissures were defined according to Craig's classification: 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.¹² Only patients with fissures in grades 3 and 4 were included in the study.

Randomization

Forty patients were randomized into 2 groups of 20. Randomization was performed intraoperatively using closed envelopes containing notes reading either "ES" for electrocautery and sealant or "ST" for conventional treatment with staplers. The groups were matched for sex, age, risk factors, duration of surgery, length of fissures, and type of lobectomy (Table 1).

Surgical Techniques

Standard lobectomy was performed via lateral or posterolateral thoracotomy according to the surgeon's preference.

Electrocautery and Sealant Group

Precision dissection of fissures, consisting of a gradual and accurate separation of lung tissue through punctate electrocoagulation and isolated application of ligatures, was conducted with the use of magnifying lenses. During the procedure, the assistant retracted the tissue of the lobe being removed as the surgeon held back the lung tissue of the other lobe with the forceps. In the other hand the surgeon held a forceps for electrocoagulation with which he/she gripped 1 small portion of tissue at a time and then coagulated it. Visible branches of the bronchial tree and larger vascular branches were ligated rather than coagulated. After completion of fissures by electrocautery, parenchymal leakage was evaluated by submersion of the resection site in saline and reventilation of the lung, applying a peak pressure of 25 to 35 cm H₂O. Leakage was graded according to Macchiarini's scale as 0 (no leakage), 1 (single bubbles), 2 (stream of bubbles), or 3 (coalescent bubbles).¹³ No other procedures were performed for all grades of leakage. The only aerostatic procedure performed in this group was the application of a sterile, ready to use, completely absorbable 9.5 × 4.8 × 0.5-cm³ collagen patch coated with human fibrinogen and thrombin (TachoSil). After premoistening with physiologic saline, with the lung moderately ventilated, the patch was easily applied by pressing it to the pulmonary surface at least 1 cm beyond the margin of dissection (Figures 1 and 2).

Stapler Group

After complete separation of fissures by routine procedure with staplers, the lung was ventilated to a pressure of 25 to 35 cm H₂O to graduate air leaks according to Macchiarini's scale.¹³ Patients with grade 3 air leakage underwent further standard techniques to reduce all leaks, including restapling, suturing, or tissue grafting, followed by repeat submersion testing until the grade of the air leaks was reduced to grade 2 or less.

After Surgery

Afterward, all patients received single drainage (28F or 32F) and were connected to a Pleur-evac system (Pleur-evac A-7000-08LF, Genzyme Surgical Products Corporation, Fall River, Massachusetts,

TABLE 1. Demographics and baseline characteristics

Variables	Procedure		Total (N = 40)	P between procedures (applied test)
	ST (N = 20)	ES (N = 20)		
Sex Male	11 (55%)	18 (90%)	29 (72%)	$P(\chi^2) = .013$
Female	9 (45%)	2 (10%)	11 (28%)	
Age (y) Mean	68.5	70.2	69.4	$P(\text{unpaired } t \text{ test}) = .431$
SD	8.1	4.5	6.5	
Maximum	81.0	81.0	81.0	
Median	68.0	70.0	69.0	
Minimum	52.0	59.0	52.0	
Risk factors Smoke	16 (80%)	16 (80%)	32 (80%)	$P(\chi^2) = 1.000$
Emphysema	5 (25%)	6 (30%)	11 (28%)	$P(\chi^2) = .723$
Job	1 (5%)	3 (15%)	4 (10%)	$P(\text{Fisher exact test}) = .605$
Duration of surgery (min) Mean	189.8	188.5	189.1	$P(\text{unpaired } t \text{ test}) = .955$
SD	66.4	73.9	69.4	
Maximum	320.0	375.0	375.0	$P(\text{Wilcoxon's 2-sample test}) = .084$
Median	185.0	180.0	180.0	
Minimum	80.0	80.0	80.0	
Length of fissures (mm) Mean	96.3	128.3	112.3	
SD	49.1	46.5	49.9	
Maximum	195.0	190.0	195.0	$P(\chi^2) = .103$
Median	105.0	95.0	95.0	
Minimum	80.0	95.0	20.0	
Operated lung right	15 (75%)	10 (50%)	25 (63%)	
Left	5 (25%)	10 (50%)	15 (37%)	
Operated lung/lobe right lower	4 (27%)	1 (10%)	5 (20%)	$P(\text{Fisher exact test}) = .117$
Lower + Medium	1 (7%)	3 (30%)	4 (16%)	
Medium	1 (7%)	1 (10%)	2 (8%)	
Upper	9 (60%)	3 (30%)	12 (48%)	
Upper + Medium	0 (0%)	2 (20%)	2 (8%)	
Total	15	10	25	$P(\text{Fisher exact test}) = 1.000$
Left lower	2 (40%)	3 (30%)	5 (33%)	
Upper	3 (60%)	7 (70%)	10 (67%)	
Total	5	10	15	
Overall lobectomy comparison by lung side				$P(\text{Cochran-Mantel-Haenszel test}) = .140$

USA) with a 7-column air leak meter. All patients initially had their chest tube placed on -20 cm H_2O suction in the operating room, in an attempt to establish initial reexpansion of the lung, and underwent chest radiography after extubation. Patients were disconnected from suction for transfer to the recovery unit. On arrival in the recovery room, patients were placed back on -20 cm H_2O suction. On the basis of results from previous randomized trials, chest tubes were always placed to water seal 48 hours after surgery.^{3,14,15}

Air leaks were catalogued twice daily according to the classification reported by Cerfolio and colleagues³ as expiratory, forced expiratory, inspiratory, or continuous and were scored from 1 to 7 by the Pleur-evac air leak meter (Figure 3). To remove the tube, the volume of drained fluids was required to be less than 100 mL during the preceding 24-hour period and all air leaks resolved.

The length of stapled tissue in the ST group and dissected parenchyma in the ES group was indirectly calculated by counting the number of staplers and TachoSil patches used. The calculated lengths were then correlated to the duration of air leaks and the moment of chest tube removal.

The estimated daily cost of hospitalization per patient was 800 euros. For each patient assigned to the ST group, 1 device complete with recharge was used, and additional recharges were supplied when necessary. The cost of each stapler was 355 euros for the device with the first recharge and 190 euros for each additional recharge. In the ES procedure, the cost of each patch was 315 euros.

Follow-up

One and 3 months after surgery, the treated patients underwent a clinical examination and chest radiography. A chest computed tomography was performed after 6 months.

Statistical Methods

All of the statistical procedures described were performed with the SAS package (SAS, Version 9.1.2; SAS Institute Inc, Cary, NC). The significance level was set to 5% ($\alpha = 0.05$) for all efficacy and safety parameters. The 2 procedures were compared by the unpaired t test or Wilcoxon's 2-sample test applied to discrete or continuous data, and by the chi-square test or Fisher exact

Figure 1. Fissure after dissection with electrocautery.

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.

Results

During the 11-month period, 40 patients (29 male [72%] and 11 female [28%]) ranging in age from 52 to 81 years (mean age 69.4 years) were included in the study and randomly assigned to each of the 2 groups. The 20 patients assigned to the ST group underwent the approved routine surgical procedure with staplers, and the 20 patients assigned to the ES group were treated with electrocautery for precision dissection and a collagen patch coated with human fibrinogen and thrombin (TachoSil) was applied for aerostasis. The demographics and baseline characteristics of the 2 groups were similar, except for a significant difference in gender distribution (ST: male 55%, female 45%; ES: male 90%, female 10%; $P = .013$).

The average length of fissures in the ES group was 128.3 mm (range 95–190 mm), and the average length of stapled

Figure 2. Fissure after positioning of TachoSil Nycomed, Vienna, Austria.

Figure 3. Pleur-evac A-7000-08LF, Genzyme Surgical Products Corporation, Fall River, Massachusetts USA with air leak meter.

parenchyma in the ST was 96.3 mm (range 80–195 mm), with no statistically significant difference (P [Wilcoxon's 2-sample test] = .084). There was no significant difference in the length of time required to perform the 2 techniques (Table 1).

Air Leaks

There was a 100% incidence of intraoperative air leaks in the ES group after electrocautery dissection and before application of TachoSil, which was higher than the incidence of 90% among patients of the ST group. The distribution of air leaks in the ES group, according to Macchiarini's scale, was as follows: 4 patients (20%) with grade 1 air leaks, 9 patients (45%) with grade 2 air leaks, and 7 patients (35%) with grade 3 air leaks. In the ST group there were 4 patients (20%) with grade 1 leaks and 14 patients (70%) with grade 2 air leaks, whereas there were no grade 3 air leaks.

Because the difference in distribution of the scores of Macchiarini's scale was significant ($P = .028$), 2 further tests were performed by grouping the severity scores as follows: first test, scores 0 to 1 versus scores 2 to 3; second test, scores 0 to 2 versus score 3. The results of the second test show that the incidence of score 3 was significantly higher in the ES group ($P = .008$) (Table 2). The significant difference in air leakage volume observed intraoperatively (ES > ST) was inverted after application of the patch and maintained for the entire postsurgical period (Figure 4). Postsurgery, the incidence in the ES group was 40% (8/20 patients), which was significantly lower than the 80% incidence of the ST group (16/20 patients) ($P = .010$); this significant difference was confirmed during the period from day 0 to the end of hospitalization (ST 95% vs ES 50%, $P = .001$).

On postoperative day 1, air leakage was detected in 7 of 20 patients (35%) in the ES group and 12 of 20 patients (60%) in

TABLE 2. Intraoperative air leaks

Variables	Procedure		Total (N = 40)	P between procedures (applied test)
	ST (N = 20)	ES (N = 20)		
Scale of Macchiarini 0	2 (10%)	0 (0%)	2 (5%)	P (Wilcoxon's 2-sample test) = .028
(score) 1	4 (20%)	4 (20%)	8 (20%)	
2	14 (70%)	9 (45%)	22 (55%)	
3	0 (0%)	7 (35%)	8 (20%)	P (χ^2) = .465
Scale of Macchiarini 0–1	6 (30%)	4 (20%)	10 (25%)	
(grouped scores) 2–3	14 (70%)	16 (80%)	30 (75%)	
Scale of Macchiarini 0–2	20 (100%)	13 (65%)	33 (83%)	P (Fisher exact test) = .008
(grouped scores) 3	0 (0%)	7 (35%)	7 (17%)	
Drainage 28	1 (5%)	2 (10%)	3 (8%)	P (χ^2) = .548
32	19 (95%)	18 (90%)	37 (92%)	

the ST group. On postoperative day 2, air leakage was detected in 4 of 20 (20%) in the ES group and 7 of 20 patients (35%) in the ST groups. The incidence of air leakage in the first 48 hours was detected in 10 of 20 patients (50%) and 19 of 20 patients (95%) in the ES and ST groups, respectively ($P = .001$). Persistent air leakage (for >7 days) was detected in 1 of 20 patients (5%) and 3 of 20 patients (15%) in the ES and ST groups, respectively ($P = .605$). The mean duration of air leaks for the trial population was 1.7 days in the ES group, significantly shorter than the 3.7 days of the ST group (P [Wilcoxon's 2-sample test] = .005) (Figure 5). The mean duration of the last occurrence of air leaks was significantly shorter in the ES group (mean 1.7 days, range 0–10 days) than in the ST group (mean 4.5 days, range 0–16 days) (P [Wilcoxon's 2-sample test] = .003) (Figure 6). The severity of air leaks, assessed by grading with the Pleur-evac device, was significantly lower in the ES group, considering both the average severity (0.5 vs 1.3, P [Wilcoxon's 2-sample test] = .004) and the maximum severity over the observation period (0.5 vs 1.5, P [Wilcoxon's 2-sample test] = .003).

*Intra-operatively before application of Tachosil®

Figure 4. Efficacy parameters: incidence of air leaks.

We determined the duration of air leak per millimeter of stapled or dissected pulmonary parenchyma from the length of the fissures. The corrected air leak durations were significantly different at 0.059 days/mm for the ST group and 0.015 days/mm for the ES group ($P < .001$).

Leak of Liquid

For each patient, the cumulative and average leak of liquid during the observation period and the days with leaks were calculated. The results do not show any statistically significant difference between procedures. In the ES group, the daily drainage leak was 270 mL versus 234.7 mL in the ST group ($P = .053$). The mean duration of liquid leaks (>100 mL/24 h) for the trial population was 7.1 in the ES group, which was shorter than the 8.4 days in the ST group (P [Wilcoxon's 2-sample test] = .837) (Figure 7).

Chest Tube

The ES group had a tube in place for a mean time of 7.6 days (range 4–13 days), whereas the mean time was 10.2 days (range 4–55 days) in the ST group. This difference (>48 hours) was not statistically significant, probably because of the small sample size (Figure 8).

We determined the chest tube removal time per millimeter of stapled or dissected pulmonary parenchyma from the length of the fissures. The corrected chest tube times were also different between the 2 groups: 0.148 days/mm stapled parenchyma in the ST group and 0.066 days/mm dissected parenchyma in the ES group ($P = .047$) (Figure 9).

Complications

The incidence of the overall complications was lower in the ES group, but the difference between procedures did not reach statistical significance. No adverse effects were observed intraoperatively or postoperatively regarding the use of TachoSil. No perioperative mortality was observed. No patient required a reoperation or blood transfusion. Transient

Figure 5. Mean values and 95% confidence interval (CI) of days with air leaks.

episodes of fever ($>38^{\circ}\text{C}$) were observed in 4 patients (3 in the ST group, 1 in the ES group), but all were resolved with empirical antibiotic therapy. Two patients, 1 from each group, experienced atrial fibrillation that necessitated pharmacologic cardioversion. One episode of left recurrent nerve palsy and 1 episode of chylothorax were the result of extensive lymphadenectomy. By extrapolating the incidence of dead pleural space, which may be considered the main postoperative complication, we observed that it was significantly lower in the ES group (ST 40% vs ES 5%; $P = .020$).

Hospitalization

The difference in mean hospitalization length of the 2 procedures did not achieve statistical significance; however, in the ES group

Figure 6. Mean values and 95% CI days to the last occurrence of air leaks.

it was 11.0 days (range 9–17 days), which was shorter than the 14.3 days (range 8–57 days) in the ST group (Figure 10).

Cost Analysis

The mean cost (euros) of the ST procedure was significantly higher than that of the ES procedure (630.5 euros for ST vs 425 euros for ES; $P = .001$). The mean cost of hospitalization, 11,440 euros (range 6400–45,600) for ST and 8760 for ES, was approximately 3000 euros lower for the experimental group; however, this difference was not statistically significant.

Discussion

Postoperative air leakage remains the major problem after lung resection.^{1,3,4} The routine use of surgical staplers does not result in adequate sealing in the majority of patients,^{2,16} which leads to prolonged chest tube drainage time, increasing the patient's risk of pleural infections, pulmonary embolism, respiratory distress, and associated pain, therefore prolonging hospital stay.^{3,13}

Many procedures, such as the application of fibrin glue,¹⁷⁻¹⁹ synthetic sealant,^{20,21} and biodegradable sealant^{22,23} reinforcement of pulmonary closure with various materials,^{24,25} and the use of laser,^{26,27} ultrasonic dissection,²⁸ and autologous blood patch¹⁰ have been proposed to control and prevent air leaks (Table 3).

This trial was designed to compare 2 different fissure completion techniques for performing a major lung resection. The use of the TachoSil patch, clearly different from its application in previous studies,^{29,30} is only a part of the procedure that was carried out. All of the parameters of air leakage—incidence, mean duration, lasting, and severity—were statistically significant with lower values for the experimental group.

We agree with Stolz and colleagues¹⁶ that staplers have a greater capacity in preventing air leaks than manual

Figure 7. Mean values and 95% CI of days with liquid leaks.

Figure 8. Mean values and 95% CI of time (days) to the drainage removal.

dissection alone. We observed a significantly greater incidence and severity of intraoperative air leaks in the ES group, but we demonstrated a relevant reduction of these on postoperative day 1 after application of TachoSil. This reduction of approximately 60% was maintained throughout hospitalization with an inversion of incidence between the 2 groups. The ES group showed a trend toward a reduction in the proportion of patients with leakage after more than 48 hours and more than 7 days, as well as a reduction in the mean leakage volumes at these times. The mean duration of the occurrence of

Figure 9. Ratio time chest tube removal/fissures length.

Figure 10. Mean values and 95% CI of hospitalization length (days).

air leaks was significantly shorter in the ES group (1.7 vs 4.5 days, $P = .003$), and the ratio between the time to the last occurrence of air leak and the length of scissure was also significantly smaller in the ES group (0.015 vs 0.059 days/mm, $P < .001$).

The multiple aspects of the better sealant results in the ES group and the ability of the regulated dissection to preserve as much pulmonary parenchyma as possible permit the residual lung to be bigger and maintain more elasticity than after being stapled with a better capacity to fill the thoracic cavity. This led to a minor incidence of complications such as dead pleural space in the ES group.

The benefits of TachoSil translated to a reduction of more than 48 hours in the mean time of chest drain removal and more than 3 days in hospitalization, although this trend did not reach statistical significance in our study because of the small size of the population from whom the results were drawn.

Inasmuch as patients must remain under clinical observation during chest drainage and tube removal is conditioned not only by the presence of air leaks but also by the liquid leaks, the period of hospitalization was not significantly reduced in the experimental group because the duration of liquid leaks was similar in the 2 groups. Although the incidence of dead pleural space was significantly lower in the ES group, the incidence of overall complications was also lower in the ES group, but the difference was not statistically significant.

Conclusions

Although this relatively small-scale study included a formal cost-saving analysis showing significant differences in the

TABLE 3. Randomized studies of sealant in lung surgery

Study	Sealant	No. patients	% AAL	Mean duration AAL (d)	% PAL	Chest tube removal (d)	Length of stay (d)
Wong and Goldstraw ¹⁷	FG	Control: 33 Experimental: 33	NA NA	4 vs 5 NS	NA NA	6 vs 6 NS	9 vs 8 NS
Fleisher and colleagues ¹⁸	FG	Control: 14 Experimental: 14	79 vs 79 NS	3.3 vs 3.2 NS	7 vs 14 NS	5.9 vs 6.1 NS	11.5 vs 9.8 NS
Macchiarini and colleagues ¹³	SLS	Control: 11 Experimental: 13	81 vs 23 NS	2.4 vs 1.9 NS	NA NA	6.9 vs 6.1 NS	14 vs 13 NS
Porte and colleagues ²⁰	SLS	Control: 61 Experimental: 59	60 vs 39 Significant	63 h vs 33 h Significant	22 vs 13 NS	NA NA	8.6 vs 9.2 NS
Wain and colleagues ²¹	SLS	Control: 55 Experimental: 117	89 vs 61.5 Significant	52.3 h vs 30.9 h Significant	7 vs 2.5 NS	4.5 vs 5.2 NS	10.1 vs 7.5 NS
Anegg and colleagues ²⁹	TachoSil	Control: 77 Experimental: 75	38 vs 30 NS	NA NA	32 vs 24 NS	6.3 vs 5.1 Significant	4.9 vs 4.6 NS
Lang and colleagues ³⁰	TachoComb Nycomed, Vienna, Austria	Control: 68 Experimental: 64	37 vs 34 NS	2 vs 1.7 NS	4.4 vs 6.2 NS	NA NA	NA NA
Droghetti and colleagues (present study)	TachoSil, Nycomed, Vienna, Austria	Control: 20 Experimental: 20	95 vs 50 Significant	3.7 vs 1.7 Significant	15 vs 5 NS	10 vs 7 NS	14.3 vs 11 NS

AAL, Alveolar air leak; PAL, persistent air leak; FG, fibrin glue; SLS, synthetic lung sealant; NA, not available; NS, not significant.

mean cost of the procedures, with ES costing less than ST (425 vs 630 euros, $P = .001$), and in the mean hospitalization cost, which was more than 2500 euros lower for the ES group, these did not reach a significant difference in our study. These results could be predictive of significant differences in chest tube removal, hospitalization, and costs in a larger population trial; however, further studies are necessary to investigate these issues.

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