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ORIGINAL ARTICLE

Bullectomy using Video-Assisted Thoracoscope versus Open Thoracotomy for Bullous Lung Disease

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ABSTRACT

Background: Spontaneous pneumothorax is commonly caused by bullous lung disease. Surgical excision is considered the gold standard for managing complicated, spontaneous pneumothorax. More thoracic surgeries have been performed with the help of video-assisted thoracoscopic surgery (VATS) in the past 20 years. This work aimed to assess the outcome of using VATS versus the conventional open thoracotomy in the management of complicated bullous lung disease. **Methods:** We enrolled 44 patients in this randomized controlled study who needed bullectomy due to confirmed complicated bullous lung disease diagnosed clinically and radiologically. Patients were randomly assigned into two equal groups (22 in each one): Group 1, which received minimally invasive VATS through the three ports approach, which was used for bullectomy, and Group 2, which was the traditional open posterolateral thoracotomy approach, was used for bullectomy. All patients were followed up clinically and radiologically.

Results: Statistically significant differences were revealed in Group1 compared to Group 2 with shorter duration for post-operative chest tube need (2.5 ± 1 versus 4 ± 0.75 days, post-operative hospital stays (5 ± 1 versus 7± 0.70 days), post-operative need for ICU stay (no cases versus six cases) and post-operative wound infection (no cases versus 5 cases). Moreover, Group 1 showed more rapid improvement of post-operative FEV 1% and FVC % than Group 2 ($p<0.001$ for each). Regarding the post-operative pain score, statistically significant differences were detected in the first and seventh days between both groups ($p<0.001$ for each).

Conclusion: For patients who have bullous lung disease resulting in spontaneous pneumothorax, VATS is a safe, practical, and efficient procedure that can be used with good results.

Keywords: Spontaneous Pneumothorax, Bullous Lung Disease, VATS, open thoracotomy.

INTRODUCTION

When bullae are seen in one or both of the lung fields alongside normally functioning lung tissue, this condition is known as bullous lung disease [1]. Emphysematous damage of the lung parenchyma causes the development of bullae, which are air-filled spaces inside the lung that are more than 1 cm in diameter [2]. Chest computed tomography (CT) is the gold standard for diagnosing bullae that become large enough to compress neighboring lung tissue. There is likely a pneumothorax associated with the bulla if a chest CT scan shows a double-wall sign, which means that air is present on both sides of the wall [3].

When patients have incapacitating dyspnea and huge bullae that cover more than 30% of the hemithorax, compressing healthy lung tissue nearby, surgical excision may be necessary. Patients with bullous disease-related problems, such as infection or pneumothorax, are also candidates for

surgery [4]. In order to resect and staple big lung bullae, most thoracic procedures use a posterolateral thoracotomy, the conventional incision. But in the past two years, surgeons have begun to favor the less invasive video-assisted thoracoscope (VATS) [5].

With the development of video-assisted surgery, cardiothoracic surgeons were able to perform thoracic cavity resections using smaller incisions and access ports. As a result, pulmonary problems and post-operative pain were less common. Minimally invasive procedures are becoming more popular for thoracic surgeries, but they cannot yet fully replace conventional methods [6].

Post-operative mortality and morbidity, recovery time, patient satisfaction, quality of life, and complications associated with the procedure are some of the factors used to determine the surgical technique's superiority [7].

Therefore, this work aimed to assess the outcome of using VATS versus the conventional open thoracotomy in the management of complicated bullous lung disease.

METHODS

We conducted this randomized controlled study at the Cardio-thoracic Surgery Department at Zagazig University Hospitals from January 2023 to December 2023; all 44 cases operated for bullectomy were considered for inclusion if they fulfilled the inclusion and exclusion criteria.

We included adults who needed bullectomy with confirmed complicated bullous lung disease diagnosed clinically and radiologically.

All cases who had management for other lung pathology, malignancy using VATS or those who had any diseases preoperatively that were related to other morbidity have been excluded from the study.

After institutional review board approval of IRB (#10361,24-1-2023), every participant gave their written informed consent. The study was conducted in accordance with the Declaration of Helsinki, which is a part of the World Medical Association's Code of Ethics for Research Involving Humans.

Pre-operative preparation

All patients were subjected to Complete history taking, including age, sex, and occupation. General and local examination of the chest to detect the presence of bullous lung disease. Radiographic assessment involving Chest X-ray and Computed tomography examinations. Pulmonary Function Tests (PFTs) were done for all patients pre- and post-operative. Laboratory studies included a complete blood count (CBC), coagulation profile, kidney function test (KFT), and liver function test (LFT) as preparation for surgery.

Surgical Procedure

Single lung ventilation using a double-lumen tube used with traditional general anesthesia was used for both groups.

Standard pre-operative, intraoperative, and post-operative aseptic techniques were followed for all patients. Patients were randomly assigned into two equal groups (22 in each group): Group (1): These patients underwent bullectomy by the minimally invasive VATS through the three ports approach. Group (2): Traditional open posterolateral thoracotomy was used to perform bullectomy for patients in this group. We used the stapler for the closure of the staple line after bullectomy in both groups. The release of any adhesions and closing off of any feeding bronchi were done. In all patients, intercostal chest drains were inserted for drainage in both groups.

Post-operative follow-up

Early Follow-up: post-operative air leak and need for chest drain duration, post-operative bleeding, ICU stay duration, thoracotomy wound pain score at days (1, 7, 30), wound infection, and hospital stay duration.

Late follow-up: Examining the patient's respiratory function and post-operative pain score (The post-operative pain was assessed using the visual analogue pain score (VAS) at post-operative days 1, 7, and 30; The visual analogue pain score describes the pain by means of numbers from 0 to 10 where 0 is no pain, and 10 is the non-tolerable pain), and chest x-ray 30 days after surgery [5].

STATISTICAL ANALYSIS

After data was processed in Excel, it was imported into SPSS, a program for statistical analysis in the social sciences (SPSS version 20.0). The quantitative continues group is represented by mean ± SD, while the qualitative data is represented by percentages. Distinct quantitative independent variables compared using analysis of variance and qualitative variables compared using Chi-square test or Fisher's exact test as appropriate. Results were considered significant when the P value was less than 0.05 and highly significant when the P value was less than 0. 001.

RESULTS

Pre-operative demographic data and patients' characteristics showed no statistically significant differences between both groups (p>0.05) (Table 1).

Table 2 showed that the mean operative time was 49.6 ± 2.7 minutes in group 1 and 79 ± 1.8 minutes in group 2. The mean intraoperative blood loss was 95.3 ± 3.1 millimeters and 173 ± 4.2 millimeters in group 1 and group 2, respectively, showing a statistically significant difference (p<0.001) between both studied groups.

The description of bullae characteristics is presented in Table 3. We found that 7 cases (31.8%) of the patients in group 1 had single bulla, while 15 cases (68.2%) had more than one bulla. Regarding the site of the bullae, in relation to the hilum, in the affected lung, 2 cases (9.1%) had basal, 10 cases (45.5%) had apical, and 10 cases (45.4%) had bullae in between apical and basal parts of the lungs. In patients included in group 2, 8 cases (36.4%) had single bulla, while 14 cases (63.6%) had more than one bulla. Regarding the site of the bullae in the affected lung, 9 cases (40.9%) had apical, 3 cases (13.6%) had basal, and 10 cases (45.45%) were in between apical and basal parts of the lung, with non-statistically significant differences between both groups.

Table 4 presents the post-operative course of the patients included in our study. Post-operative chest tube duration was 2.5 ± 1 days in group 1 and 4 ± 0.75 days in group 2. Post-operative need for ICU stay was 0% in group 1 and 25% in group 2. Moreover, the mean post-operative hospital stay duration was 5 ± 1 days in group 1 and 7± 0.70 days in group 2. No patients had post-operative wound infection in group 1, while five patients had thoracotomy wound infection in group 2, with statistically significant differences between both groups (p<0.001, <0.001<0.001, and 0.032, respectively).

Pulmonary function tests were performed for all the studied patients preoperatively and 30 days postoperatively. Pre-operative FEV% and FVC% showed non-significant differences. However, there was a statistically significant difference (p<0.001) between both groups regarding the mean post-operative FEV1 % (81 ± 9 and 73 ± 10.64) and post-operative FVC % (79 ± 4 and 73 ± 4.5) in groups 1 and 2 respectively (Table 5).

The post-operative VAS score showed a statistically significant difference between the patients in both groups on $^{\text{the first}}$ post-operative day (3 ± 1 in group 1 versus 6.5 ± 1.02 in group 2) and $^{\text{seventh}}$ post-operative day (2.4 ± 1in group 1 versus 5 ± 1.08 in group 2) with p<0.001 for each (Table 6).

Table 1: Pre-operative demographic data of patients in both studied groups

	Group 1 VATS (N=22)	**Group 2 Thoracotomy (N=22)**	**P value**
Age			
Mean ± SD	29.2 ± 2.6	29.4 ± 2.4	0.891
(Min-Max)	(18-63)	(19-52)	
Sex: Female Male	 4 (18.2%) 18 (81.8%)	 3 (13.6%) 19 (86.4%)	1.000
BMI			
Mean ± SD	24.6 ± 0.7	26.2 ± 0.64	0.09
(Min-Max)	(20.6-30.3)	(23.3-31.2)	
Comorbidities			
Hypertension	3 (13.6%)	6 (27.3%)	0.265
Diabetes	6 (27.3%)	3 (13.6%)	0.265
Smoking	6 (27.3%)	3 (13.6%)	0.265

VATS: Video-assisted thoracic surgery, BMI: Body Mass Index; SD: standard deviation

Table 2: Intraoperative time and blood loss in both studied groups

	Group 1 VATS (N=22)	Group 2 Thoracotomy (N=22)	P value
Operative time (min)			
Mean ± SD	49.6 ± 2.7	79 ± 1.8	**<0.001****
(Min-Max)	(64-75)	(96-103)	
Intra-operative blood loss			
Mean ± SD	95.3 ± 3.1	173 ± 4.2	**<0.001****
(Min-Max)	(89-101)	(162-177)	

VATS: Video-assisted thoracic surgery, SD: standard deviation.

Table 3: Bullae characteristics and other lung lesions in the studied patients of both groups

	Group 1 VATS (N=22)	Group 2 Thoracotomy (N=22)	p-value
Number of bullae			
One bullae	7 (31.8%)	8 (36.4%)	**1.000**
Two bullae or more	15 (68.2%)	14 (63.6%)	
Mean ± SD	1.3 ± 0.81	1.1 ± 0.67	**0.851**
Site of bullae			
Apical	10 (45.5%)	9 (40.9%)	**0.761**
Basal	2 (9.1%)	3 (13.6%)	**0.642**
In between apical and basal	10 (45.4%)	10 (45.45%)	**0.549**
Size of bullae			
1 cm	7 (31.8%)	6 (27.3%)	**0.746**
1-3 cm	7 (31.8%)	12 (54.5%)	**0.133**
More than 3 cm	8 (36.4%)	6 (27.3%)	**0.522**
Mean ± SD	2.4 ± 1.23	2.1 ± 0.97	**0.882**

VATS: Video-assisted thoracic surgery, SD: standard deviation.

Table 4: Post-operative course and complications in the studied groups

	Group 1 VATS (N=22)	Group 2 Thoracotomy (N=22)	P value
Post-operative chest tube duration (days)			
Mean ± SD	2.5 ± 1	4 ± 0.75	**<0.001****
(Min-Max)	(2-4)	(3-6)	
Post-operative hospital stay (days)			
Mean ± SD	5 ± 1	7± 0.70	**<0.001****
(Min-Max)	(3-5)	(7-10)	
Post-operative need for ICU stay/day			
N (%)	0 (0%)	6 (25%)	**<0.001****
Post-operative wound infection	0 (0%)	5 (22.7%)	**0.032***

VATS: Video-assisted thoracic surgery, SD: standard deviation; N: number; Min: minimum; Max: maximum

Table 5: Post-operative pulmonary function tests in both studied groups

	Group 1 VATS (N=22)	Group 2 Thoracotomy (N=22)	P value
Pre-operative FEV1 %			
Mean ± SD	63 ± 9	69 ± 11.13	**0.467**
(Min-Max)	(47-80)	(49-88)	
Post-operative FEV1 %			
Mean ± SD	81 ± 9	73 ± 10.64	**<0.001****
(Min-Max)	(61-97)	(53-100)	
Pre-operative FVC %			
Mean ± SD	70 ± 7	70 ± 6.12	**0.891**
(Min-Max)	(53-78)	(59-86)	
Post-operative FVC %			
Mean ± SD	79 ± 4	73 ± 4.5	**<0.001****
(Min-Max)	(71-88)	(62-81)	

VATS: Video-assisted thoracic surgery, FEV1: forced expiratory volume in 1st second; FVC: forced vital capacity; SD: standard deviation; N: number; Min: minimum; Max: maximum

Table 6: Post-operative VAS pain score in both studied groups

	Group 1 VATS (N=22)	Group 2 Thoracotomy (N=22)	P value
Post-operative pain score on day 1			
Mean ± SD	3 ± 1	6.5 ± 1.02	**<0.001****
(Min-Max)	(2-5)	(2-8)	
Post-operative pain score on day 7			
Mean ± SD	2.4 ± 1	5 ± 1.08	**<0.001****
(Min-Max)	(1-5)	(1-5)	
Post-operative pain score on day 30			
Mean ± SD	2 ± 1	2 ± 0.9	**0.891**
(Min-Max)	(0-4)	(0-3)	

VAS: Visual analogue scale, SD: Standard Deviation; N: number; Min: minimum; Max: maximum.

DISCUSSION

A serious cause of respiratory complications is bullous lung disease. The functional impairment of pulmonary mechanics, decreased exercise capacity, and abrupt respiratory distress can be caused by distinct emphysematous bullae in patients with severe emphysema [8].

It is important to distinguish between simple large bullae and vanishing lobes or segments when considering an elective procedure for bullous emphysema. If the bullae only cover a third of the hemithorax, it is not worth the risk of surgery to try to remove them. This is because the operation will not improve the patient's pulmonary function or validity [9].

There is little risk of complications, a high success rate, and reasonable expense when using video-assisted thoracoscopic surgery [10]. Post-operative mortality and morbidity, recovery time, quality of life, patient happiness, and complications associated with the procedure are some of the factors used to evaluate which surgical approach is better [6].

This work aimed to assess the outcome of using VATS versus the conventional open thoracotomy in the management of complicated bullous lung disease.

The present study showed that the description of bullae characteristics showed non statistically significant differences between both groups (p>0.05). Abdullah et al. [11] also, reported non statistical significant differences between both groups regarding description of bullae characteristics (P>0.05).

Our study showed that the mean operative time was 49.6 ± 2.7 minutes in group 1 and 79 ± 1.8 minutes in group 2. The mean intraoperative blood loss was 95.3 ± 3.1 liters and 173 ± 4.2 liters in group 1 and group 2, respectively, showing a statistically significant difference (p<0.001) between both studied groups. These results agreed with a study done by Cheang et al. [12], who involved in their systematic review of eight studies that showed that VATS considerably reduced the amount of time it took to operate compared to open thoracotomy, with a mean difference of -46.37 minutes (p<0.001).

Moreover, Alanwar et al. [13] found that the thoracotomy group required more time for the operation compared to the VATS group and that the thoracotomy group also required significantly more blood throughout the procedure (p<0.001).

Additionally, Laohathai al. [14] observed that the groups undergoing open thoracotomy had a longer operating time and higher blood loss than the groups undergoing VATS (180 minutes versus 70 minutes, p<0.001 and 100 mL versus 30 mL, p<0.001).

Also, two systematic review studies done by Vohra et al. [15] and Lin et al. [16] revealed that VATS minimizes intraoperative blood loss and operating time compared to open thoracotomy.

In the present study, post-operative chest tube duration was 2.5 ± 1 days in group 1 and 4 ± 0.75 days in group 2. Post-operative need for ICU stay was 0% in group 1 and 25% in group 2. Moreover, the mean post-operative hospital stay duration was 5 ± 1 days in group 1 and 7± 0.70 days in group 2. No patients had post-operative wound infection in group 1, while five patients had thoracotomy wound infection in group 2, with statistically significant differences between both groups (p<0.001, <0.001<0.001, and 0.032, respectively). This also agreed with Atkins et al. [17] as Group VATS had less complication in post-operative wound infection than the open thoracotomy (p<0.05) [17].

Also, Laohathai et al. [18] compared two groups (uniportal vs standard three-port VATS technique) and found that the VATS group had a significantly shorter hospital stay (9.5 days vs. 15 days, p=0.006).

Studies proved that chest tube removal can be performed earlier in VATS patients compared to open thoracotomy. This is attributed to the less invasive nature of VATS, resulting in reduced post-operative pain and faster resolution of air leaks [18,19].

Laohathai et al. [14] intended to evaluate the effectiveness of primary spontaneous pneumothorax (PSP) surgery using video-aided thoracoscopic surgery (VATS) vs. open thoracotomy in terms of recurrence, post-operative complications, length of hospital stay, and cost-effectiveness. When comparing the groups that underwent open thoracotomy to those that underwent VATS, the former had a longer operating time (180 minutes versus 70 minutes, p<0.001) and less blood loss (100 mL versus 30 mL, p<0.001). Compared to open surgery, our research shows that VATS bullectomy significantly improved the dyspnea index.

Regarding post-operative pain, we found the post-operative VAS score showed a statistically significant difference between the patients in both groups on $^{\text{the first}}$ post-operative day (3 ± 1 in group 1 versus 6.5 ± 1.02 in group 2) and $^{\text{seventh}}$ post-operative day (2.4 ± 1in group 1 versus 5 ± 1.08 in group 2) with p<0.001 for each. Pain was recorded on three fixed points: 1, 7, and at 30 days post-operative. We found a high statistically significant (p<0.001) decrease in pain score over time post-operative, reaching the lowest level after one month. Increased acute pain score postoperatively, especially during the hospitalization period, causes higher morbidity due to sputum retention with resulting chronic post-thoracotomy pain syndrome [12]. Reduce the risk of complications such as atelectasis, pneumonia, pulmonary embolism, and admission to the critical care unit by effectively managing pain after a thoracotomy. In addition, the complications of hypoxemia, hypercarbia, ischemia, and arrhythmias can be resolved by early ambulation and effective respiratory physiotherapy [11].

Furthermore, After thoracic surgery, pulmonary complications are among the leading causes of death and disability in the post-operative period. Atelectasis, pneumonia, and respiratory failure are the main respiratory consequences. The majority of the anticipated 3% to 4% mortality is attributable to

these, which affected 15-20% of patients [20]. On the first post-operative day, Ismail et al. [20] found that all patients had moderate pain (score 4,5,6). On the seventh post-operative day, 2.5% had no pain (score 0), 84.9% had mild pain (score 1,2,3), and 15.1% had moderate pain (score 4,5,6). After one month post-operative, 46.5% had no pain (score 0), 44.2% had mild pain (score 1,2,3), and 9.3% had moderate pain (score 4,5,6). This indicates an interesting decrease in pain over one month post-operative. This enabled patients to recover earlier and restore their normal function and life practice.

Patients in the VATS group had a greater recurrence risk of pneumothorax than those in the thoracotomy group (3.8 percent vs. 1.8 percent), according to research by Page et al. [21].

Pulmonary function tests were performed for all the studied patients preoperatively and 30 days postoperatively. Pre-operative FEV% and FVC% showed non-significant differences. However, there was a statistically significant difference ($p<0.001$) between both groups regarding the mean post-operative FEV1 % (81 ± 9 and 73 ± 10.64) and post-operative FVC % (79 ± 4 and 73 ± 4.5) in groups 1 and 2 respectively.

By comparing subjective dyspnea scores before and after surgery, as well as pulmonary function and clinical characteristics, Lone et al. [22] intended to assess the efficacy of surgery for bullous lung disease. Within three to six months after surgery, the average forced expiratory volume in one second (FEV1), forced vital capacity (FVC), and FEV1/FVC were 2.18 ± 0.49 L, 3.15 ± 0.65 L, and 69.47 ± 11.28 percent, respectively, according to their study. There was a statistically significant improvement in mean forced vital capacity (FVC), forced expiratory volume (FEV1), and FEV1/FVC from pre-operative values to those measured 3-6 months after surgery. The highest connection was observed for FEV1 values. We think that the difference between the results in our study and in the Lone et al. study is due to their longer follow-up duration.

Limitations

Limitations should be considered when interpreting the findings of our study. Firstly, the relatively small sample size of both minimally invasive VATS and traditional open posterolateral thoracotomy for the bullectomy approach may limit the generalizability of our results to a broader population. Furthermore, the short follow-up duration may not capture long-term outcomes and complications associated with bullectomy in both groups. Finally, the study did not investigate potential variations in surgical techniques or the experience of the surgical teams, which could influence outcomes. These limitations highlight the need for larger, prospective studies with longer follow-up periods and more comprehensive data collection to further elucidate the optimal approach for bullectomy.

CONCLUSIONS

Patients exhibiting spontaneous pneumothorax and bullous lung disease, whether or not accompanied by a broncho-pleural fistula or parenchymal leak, can be successfully treated with VATS, which is a safe, practical, and efficient approach. Because of the higher functional outcome and reduced perioperative morbidity, it should be chosen over open thoracotomy whenever possible.

Conflict of interest: None

Financial Disclosure: None

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