Video-assisted thoracoscopic treatment of giant bullae associated with emphysema

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Abstract

Objective: Surgical treatment of bullous emphysema has received renewed attention because of recent advances in minimally invasive techniques. We describe our experience in the thoracoscopic management of patients with bullous emphysema over the last 5 years.

Methods: Twenty-five patients (24 male, one female) with a mean age of 57 years with giant bullae associated with various degree of underlying emphysema, were operated on thoracoscopically at our Institution. The severity of the emphysema was classified according to the criteria of the American Thoracic Society: five patients were in stage I (FEV1 > 50%), eight patients were in stage II (FEV1 35 to 49%) and 12 patients were in stage III (FEV1 < 35%). Nine patients underwent operation to treat complications related to bullae, 12 presented dyspnoea and four were asymptomatic. We performed 23 unilateral and two bilateral staged thoracoscopic procedures. Results: No intra-operative complications developed. Mean operative time was 107 ± 25 min. No patient dead. Mean post-operative chest tube duration was 8 ± 4.13 days and mean post-operative hospital stay was 11 ± 5.76 days. The most frequent post-operative complication was air-leakage that in 12 patients lasted more than 7 days. Pulmonary function tests were obtained 3±6 months after the operation and statistical comparison between pre-operative and post-operative data was performed using Student’s paired t-test. We observed best results in I and II stage patients, but also stage III patients experienced clinical improvement and better quality of life. Conclusions: Our experience supports the safety and effectiveness of video-assisted thoracoscopy for the treatment of giant bullae. Minimally invasive approach is fully justified especially in the group of patients with severe impairment of lung function. © 1999 Elsevier Science B.V. All rights reserved.

Keywords: Thoracoscopy; Bullous emphysema

1. Introduction

Surgical resection of large emphysematous bullae is a well established procedure that may significantly improve symptoms, exercise tolerance, respiratory reserve and eventually treat complications [1–4]. Selection of those patients who could benefit from surgery is both difficult and still controversial. A wide variety of surgical procedures have been proposed in the management of bullous emphysema such as intra-cavitary drainage [5], local excision of the bullae [6], plication [7], stapler resection [8], lobectomy [9], usually accomplished through an open approach, such as thoracotomy or sternotomy [10]. Introduction of video-assisted thoracoscopy (VAT) has increased interest in using this minimally invasive approach for many thoracic surgical procedures. Because patients with severe emphysema do not tolerate thoracic surgical operations very well, it has become widely accepted that such operations should be accomplished with minimal surgical trauma. This study describes our experience in the thoracoscopic management of giant emphysematous bullae in patients with different degree of underlying emphysema.

2. Materials and methods

Over the last 5 years, 25 patients (24 male, one female), with a mean age of 57 years (range 32–76 years) with large emphysematous bullae were operated on thoracoscopically at our institution. In order to classify preoperatively the extent of the disease on the basis of chest computed tomography scan findings, we grouped our patients using the classification proposed by Witz and Roeslin in 1980 [11]. Four patients were included in the group I: bullae associated with almost normal parenchyma; 21 patients were classified...
five patients were in stage I (FEV1 \( < 70 \% \)) and eight patients in stage II (FEV1 35–49\%) and 12 patients were in stage III with a FEV1 < 25\% of predicted. In 12 patients, the indication for surgical bullectomy was dyspnea. Ten patients were on oxygen support. Nine (one patient in stage I, five patients in stage II and three patients in stage III) patients underwent operation to treat complications: pneumothorax in five, chest pain in three and empyotis in one. In four asymptomatic patients (all in stage I) surgery was justified because of very large bullae occupying half or more of the emitorax. Preoperative evaluation included spirometry, whole body plethysmography, blood gas analysis, diffusion of carbon monoxide (DLCO), chest X-ray, high resolution computed tomography of the chest (HRCT), ventilation-perfusion scan and cardiac status assessment. Patients with severe underlying emphysema underwent intensive rehabilitation program including physical therapy, optimization of medical treatment and cessation of smoking before operation in order to improve pulmonary function and reduce operative risk.

### 2.1. Thoracoscopic technique

Video-assisted thoracoscopy was performed under general anesthesia with double lumen intubation. High frequency jet ventilation was employed in six patients unable to tolerate single lung ventilation. We performed 23 unilateral and two bilateral staged procedures. Usually three to four intercostal accesses were employed. Before proceeding with the bullectomy, all parietal adhesions were excised. Bullectomy was accomplished using 45 or 35 mm endoscopic staplers. Giant bullae still hyper-inflated after proceeding to single lung ventilation were opened for deflation or shrunk by non-contact Nd:Yag laser coagulation. The laser beam was cast from a distance of 2.5–3 cm, at the power setting between 35 and 40 W. During the operation, all efforts were applied to prevent or minimize post-operative air-leakage. In six cases an apical pleural tent was prepared thoracoscopically to wrap the lung and reduce the pleural space. The parietal pleura was mobilized starting from the upper intercostal incision. Then the pleura was dissected down from the endothoracic fascia, and the extra-pleural dissection was performed under direct vision, introducing the scope into the extra-pleural space. Fibrin or synthetic cyanoacrilate based glue and bovine pericardium both or singularly were employed to seal and to buttress the stapler’s lines. Once bullectomy was accomplished, careful inspection of the stapler line was done and in three cases significant air-leakage was demonstrated and treated by additional application of endoscopic stapler and surgical glue. In some cases, lower pulmonary ligament was transacted to allow a better lung re-expansion. Two chest tubes were left in place and connected to a water seal under 10–15 cm H2O of suction.

### 3. Results

No intra-operative complications developed. All patients were extubated in the operating room at the completion of the procedure. The mean operative time was 107 ± 25 min. No patient died. The mean post-operative chest tube duration was 8 ± 4.13 days and mean post-operative hospital stay was 11 ± 5.76. The most frequent post-operative complication was the air-leakage that in 12 patients lasted more than 7 days. The mean chest tube duration in the subgroup of patients with pleural tent was 6 ± 2.1 days.

One patient presented a self-limiting bleeding that required transfusion of three units of blood. One patient developed gastric perforation on the 2nd post-operative day which was treated successfully by an emergency laparotomy. Five patients required fiber-bronchoscopy to remove dense secretions, three presented cardiac arrhythmia, one had a limited empyema treated with antibiotic therapy. Pulmonary function tests were obtained 3–6 months after the operation. Results are reported in Table 1.

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**Table 1**

Comparison of preoperative and post-operative lung function tests^a^

<table>
<thead>
<tr>
<th></th>
<th>Stage I (5 Pts)</th>
<th>Stage II (8 Pts)</th>
<th>Stage III (12 Pts)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-Op</td>
<td>Post</td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>FEV1 (%)</td>
<td>55 ± 4.8</td>
<td>61 ± 2.7</td>
<td>38 ± 2.6</td>
<td>49 ± 4.2</td>
</tr>
<tr>
<td>MVV (%)</td>
<td>59 ± 3.6</td>
<td>66 ± 3.9</td>
<td>41 ± 1.6</td>
<td>56 ± 4.8</td>
</tr>
<tr>
<td>FRC (L) (Pleth)</td>
<td>4.1 ± 0.7</td>
<td>3.2 ± 0.2</td>
<td>4.7 ± 0.2</td>
<td>3.6 ± 0.4</td>
</tr>
<tr>
<td>FRC (L) (He)</td>
<td>2.9 ± 0.2</td>
<td>2.8 ± 0.1</td>
<td>3.1 ± 0.3</td>
<td>2.9 ± 0.1</td>
</tr>
<tr>
<td>PaO2 (mmHg)</td>
<td>74 ± 5.1</td>
<td>78 ± 4.2</td>
<td>65 ± 4.1</td>
<td>70 ± 2.9</td>
</tr>
<tr>
<td>PaCO2 (mmHg)</td>
<td>38 ± 1.6</td>
<td>39 ± 0.7</td>
<td>40 ± 1.1</td>
<td>39 ± 0.9</td>
</tr>
<tr>
<td>DLCO (%)</td>
<td>48 ± 3.7</td>
<td>55 ± 2.8</td>
<td>38 ± 2.3</td>
<td>48 ± 4.5</td>
</tr>
</tbody>
</table>

^a^ Statistical analysis was performed by a Student’s paired t-test.
as mean ± standard deviation. Statistical comparison between pre-operative and post-operative data was performed using Student’s paired t-test. In general, we observed better functional results in stage I and II of ATS. Stage III patients also experienced reduction in air trapping, increases in expiratory flow rates, gas exchange arterial oxygenation and exercise tolerance (Fig. 1). In six out of 10 patients it was possible to discontinue oxygen support and in four it was reduced. Steroid therapy was suspended in six and tapered in four.

4. Comment

Surgical resection of giant occupying space emphysematous bullae allows the compress functioning lung to re-expand, permits a better ventilation and perfusion, decrease both dead space and residual volume and improves the chest mechanics with remodelling of the diaphragm and the chest wall [13]. Surgical bullectomy is indicated for patients with dyspnoea having compressive space-occupying non-functioning bullae developed on near normal or emphysematous lung. Surgery is also indicated to treat complications. In our series, nine patients underwent thoracoscopy to treat complications related to the bullae. Preventive bullectomy in asymptomatic patients is controversial. In four completely asymptomatic patients, surgical bullectomy was justified for the presence of giant bullae occupying half or more of the emithorax, showing progressive enlargement of the bullae during the last year or deterioration of lung function. The key to obtain good results is proper selection of patients [14]. No single preoperative exam is considered to be an absolute predictor of post-surgical improvement and there are no absolute indications or contraindications to the operation. Pre-operative evaluation should be accurate to identify patients with an acceptable surgical risk and to assess the status of the underlying lung in terms of potential re-expansion and function once the bullae have been removed. Surgical results and perhaps also long term outcome appear to be related much more to the severity of the underlying emphysema than the size and morphology of bullae. For this reason we believe that COPD staging according to ATS classification is a better predictor of outcome in this subset of patients. We observed best results in stage I and II patients. Stage III patients, presented limited functional data increment but they experienced clinical improvement in terms of exercise tolerance, oxygen requirement, medical support and definitely better quality of life. On the contrary, some authors [13] remarked that functional improvement after bullectomy is unsatisfactory in patients with pre-operative FEV1 < 35% of predicted value, severe reduction of DLCO capacity, hypoxemia and hyper-capnia. Our data support that the presence of diffuse emphysema and severe impairment of lung function (stage III of ATS) should not exclude consideration for surgery because in this subset of patients even a small increment in breathing capacity may improve symptoms, exercise tolerance and quality of life. Nevertheless, long term follow-up studies have shown that many of these changes are inconstant and new progressive deterioration is described [15]. Once indication for surgery has been established in such patients, an intensive pre-operative

Fig. 1. (A) Chest X-ray showing bilateral large emphysematous bullae with decreased vascular markings in the upper lobes area and flattening of the hemidiaphragms. Preoperative FEV1 was 12% of predicted. (B) Chest CT-scan of the same patient demonstrates bilateral extensive bullous disease associated with diffuse emphysema. This patient underwent bilateral staged thorascopic bullectomy. (C) Post-operative chest CT-scan of the same patient taken 6 months after the second operation, showing complete lung re-expansion. Clinical status and lung function markedly improved.
physiotherapy, optimization of medical therapy and smoke cessation may result in an improvement of lung function and a reduction of the operative risk.

In our opinion, on the basis of pre-operative lung function tests, level of chronic breathlessness and patho-physiologic derangement, patients with giant bullae associated with severe lung emphysematous changes may be considered similar to patients with non-bullous emphysema candidates to volume reduction surgery. Bullectomy and pneumoplasty essentially allow to remove redundant space occupying destructed emphysematous lung. Improvement after surgery can be essentially explained after both the procedures with reduction of residual volume and thoracic hyperinflation, re-expansion of adjacent compressed lung, improvement in respiratory muscle strength, chest wall mechanics and intra-thoracic haemodynamics [16,17]. We believe that bullectomy, when technically feasible, should be performed by limited resections using a minimally invasive approach to preserve all potentially functioning lung tissue with minimal surgical trauma [18–20]. VAT allows performance of the same surgical maneuvers accomplished through an open approach. For bilateral bullous disease, we agree with others [8] that it is preferable to perform two stage thoracoscopic operations. This strategy facilitates evaluation of the functional result after the first operation and further deterioration might indicate for removing contra-lateral bullae.

Most of these patients with bullous emphysema are elderly, with severe impairment of lung function. Early post-operative vigorous physiotherapy should be started to allow a complete lung re-expansion, clearance of secretions. A very important technical point is to prevent air-leakage and post-operative residual air spaces. Despite this several surgical techniques are available to prevent air-leaks [21–23], none of these may be sufficient especially if the underlying lung tissue is severely damaged. We believe that pleural tent represents a good technical choice for protecting the mechanical sutures wrapping the lung surface and can prevent the development of post-operative pleural spaces [24]. Our experience supports the safety and effectiveness of the video-thoracoscopic approach for the management of giant bullae associated with emphysema. This minimally invasive approach should not be still considered an investigational procedure [25] and in our current practice, it represents the first option for the management of giant bullous emphysema and lung volume reduction surgery.

References


Appendix A. Conference discussion

Dr T. Lerut (Leuven, Belgium): I have two small technical questions. Have you had any experience with the loop ligation or elastic band ligation of the bullae, which is applied by some Japanese groups, and which obviously could be helpful in avoiding prolonged leak? And secondly, you spoke about the use of the Nd:YAG laser. I think many people have
tried that and abandoned that. Do you have any specific indication where you still think that Nd:YAG laser can be an advantage?

**Dr De Giacomo:** First of all, we do not have any experience with bullae ligation, so I can not add anything about this technical point. About the use of Nd:YAG laser, we used it in some cases to shrink the bullae before resecting them with the endoscopic stapler. The laser application allowed to reduce the volume of the larger bullae avoiding their opening deflation.

**Dr Dougenis (Patras, Greece):** Although I would agree with you that there is a place for the VAT in the management and the treatment of bullous emphysema disease, I am a bit concerned with your paper because it seems to me that you’re mixing two different diseases, the giant bulla and the diffused lung emphysema. And I would think that we shouldn’t generalize and make particular conclusions by analyzing two different subsets of patients, because they behave differently.

**Dr De Giacomo:** Pulmonary emphysema can present many different aspects. Sometimes you can find giant bullae associated with normal or almost normal parenchyma, but on the other hand bullae can be found associated with serious emphysema. This study reports our experience especially in this particular subset of patients.

**Dr Dougenis:** But actually you didn’t do a proper lung volume reduction procedure on the patients with the giant bullae, you just resected the bullae, right?

**Dr De Giacomo:** Yes, this series of patients underwent thoracoscopic bullectomy.

**Dr Dougenis:** You didn’t do a proper lung volume reduction procedure on the patients with the giant bullae, you just resected the bullae, right?

**Dr De Giacomo:** No, we did not perform a proper lung volume reduction surgery.

**Dr J-M. Wihlm (Strasbourg, France):** I would like to exactly emphasize what was just said there. Because you mentioned classification coming from Strasbourg, you didn’t give your results according to this classification, first. And second, I totally agree, you showed us a kind of congenital, unique bullae associated with normal parenchyma on the CT scan and this is totally different. So you are mixing resection of giant bullae and surgery on bullae in emphysematous patients and you can’t mix all this. I don’t agree if you say you have giant bullae on severe emphysema. On the normal chest X-ray and on the CT scan, it was obvious that the other side, the left side, was normal. I think thoracoscopic procedures are only an option for the treatment of these patients and I think there are recent papers arguing this and still considering the more classical surgery with very musclesparing thoracotomies, so you can better assess every area of your lung and really tailor your operation to better site placement of the staples or whatever means you have. And maybe you can have a better control of the air leaks because, as everybody knows, in thoracotomy it is not so easy to use any new means, including glues or whatever you have from the company now, for reducing the leaks.

**Dr De Giacomo:** First of all, only five patients in this series presented emphysematous bullae associated with normal or almost normal parenchyma.

**Dr Wihlm:** So this is a subgroup you should have identified.

**Dr De Giacomo:** This is a subgroup of patients with non-congenital bullous emphysema, in which the underlying lung was still well conserved. Congenital air-cysts is a different pathology. Most of our patients presented severe emphysema associated with bullous disease. These patients in my opinion should be separated from patients with emphysema and bullae, the removal of bullous lesions works as well as resection of bullae work such as volume reduction surgery. I mean that when you do bullectomy in this subgroup of patients you remove non-functioning redundant pulmonary occupying space tissue, allowing the remaining lung to work better, and to improve ventilation. About the choice of surgical approach, I believe that thoracoscopy is a good option for doing bullectomy in these patients and it is possible to perform the same surgical maneuvers that you usually do through an open approach. In our experience, thoracoscopic operations present an acceptable rate of complications. Thoracoscopy is well tolerated by patients with less post-operative pain and early mobilization. We observed similar or better results than those obtained by open approach.

**Dr Wihlm:** Yes, but to prove this, you have to make a comparison between series.

**Dr De Giacomo:** Yes, you are right.

**Dr Wihlm:** And even in a prospective study, not a retrospective one.

**Dr De Giacomo:** This is what we are planning to do.

**Dr J. Hasse (Freiburg, Germany):** Pathophysiologically a single bulla is not equivalent to bullous emphysema. Therefore, it should be considered a different disease. The majority of the audience seems to agree with this view.

**Dr Dosios:** How many of your patients could not tolerate one lung ventilation? Because you said that it was necessary in some of them to give jet ventilation.

**Dr De Giacomo:** Five patients in our series required jet ventilation.

**Dr Dosios (Athens, Greece):** According to your experience, you concluded that VA is a good option for these patients. Do you think that there is any place at all for open thoracotomy, either lateral or through the median sternotomy, for these patients, or do you think all of these patients should be operated on with VAT?

**Dr De Giacomo:** Thoracoscopy is only a good surgical option. Anyway, I believe that in this group of patients especially those with severe emphysema and impairment of lung function, minimally invasive surgery should be the goal. In some cases, in presence of obliteration of the pleural space or when it is difficult to mobilize the lung or accomplish the procedure, thoracoscopy can be converted to an open procedure.