Sternal-sparing approach for reoperative bilateral lung transplantation

Jay K. Bhama^{a,*}, Aditya Bansal^b, Norihisa Shigemura^a, Christian A. Bermudez^a and Yoshiya Toyoda^c

^a Division of Cardiac Surgery, Department of Cardiothoracic Surgery, University of Pittsburgh Medical Center, Pittsburgh, PA, USA

^b Department of Cardiothoracic Surgery, Ochsner Clinic, New Orleans, LA, USA

^c Department of Cardiothoracic Surgery, Temple University Medical Center, Philadelphia, PA, USA

* Corresponding author. Department of Cardiothoracic Surgery, University of Pittsburgh Medical Center, 200 Lothrop Street, C-924, Pittsburgh, PA 15213, USA.
Tel: +1-412-6486315; fax: +1-412-6922948; e-mail: bhamajk@upmc.edu; bhamajk@yahoo.com (J.K. Bhama).

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Abstract

OBJECTIVES: A sternal-sparing approach for bilateral lung transplantation was recently applied to reoperative lung transplant cases and is compared with the traditional clamshell approach.

METHODS: A retrospective analysis of 15 consecutive reoperative bilateral lung transplants performed from January 2008 to April 2011 was conducted. Outcomes were compared between the first 11 patients who underwent the traditional clamshell and the most recent 4 patients who underwent the sternal-sparing approach.

RESULTS: The indication for retransplantation was obliterative bronchiolitis in all patients. Both groups were similar with regard to age, allograft ischaemic time and operative time. Cardiopulmonary bypass was more frequent in the sternal-sparing group although required for a shorter period of time. The need for postoperative extracorporeal membrane oxygenation for primary graft dysfunction was similar in both groups. The length of ICU care and total hospitalization length of stay were similar for the sternal-sparing group compared with the traditional clamshell approach. Operative mortality and overall survival also did not differ.

CONCLUSIONS: Reoperative bilateral lung transplantation with a sternal-sparing approach is feasible and may yield outcomes similar to those in the traditional clamshell approach. Further analysis with larger numbers of patients is warranted to delineate the benefits of this approach for patients requiring reoperative lung transplantation.

Keywords: Lung transplantation • Reoperative • Redo • Sternal-sparing • Bilateral

INTRODUCTION

Reoperative lung transplantation is becoming a more commonly performed operation in the USA [1]. Due to the technical challenges associated with this tour-de-force of surgery, most centres utilize a large thoracosternotomy [clamshell (CS)] incision (Fig. 1A). While this incision provides excellent surgical exposure, it is an incision typically associated with significant postoperative pain, debilitation and a relatively lengthy recovery period. The risk of sternal wound complications is also a common potential problem with the CS incision.

In 2008, our centre started utilizing an alternative approach for primary lung transplantation involving a sternal-sparing, bilateral anteroaxillary thoracotomy (BAT) [2]. This has become the standard approach in our programme for primary single or bilateral lung transplantation and has essentially replaced the conventional CS incision (Fig. 1). This sternal-sparing approach for lung transplantation was recently applied to reoperative lung transplant cases. Herein, we describe our initial experience with this

approach and compare early outcomes with those in patients undergoing the traditional CS technique.

MATERIALS AND METHODS

Approval for retrospective review of our transplant database was obtained from the University of Pittsburgh Medical Center Total Quality Control Council. Reoperative lung transplantation for chronic allograft dysfunction was performed in 15 consecutive adults from January 2008 to December 2011. Outcomes were compared between the first 11 patients who underwent the traditional clamshell approach (CS group) and the most recent 4 patients who underwent the sternal-sparing bilateral anteroaxillary approach (BAT group).

All patients received induction therapy with rabbit antithymocyte globulin, alemtuzumab or daclizumab. Our protocols for immunosuppression management, diagnosis/treatment of acute rejection and infection prophylaxis have been described previously [3].

Figure 1: Progression of surgical approach from ‘clamshell’ thoracosternotomy (A) to sternal-sparing anteroaxillary thoracotomy for primary lung transplant (B), and recently to reoperative lung transplant (C). Arrow indicates the previous CS incision.

Table 1: Comparison of demographic and perioperative characteristics of the control and study groups

Characteristic	BAT (n = 4)	CS (n = 11)	P-value
Age (years)	42 ± 8	44 ± 4	NS
Indication for initial transplant			
CF	2 (50%)	6 (55%)	NS
IPF	1 (25%)	0 (0%)	
COPD	1 (25%)	4 (36%)	
Other	0 (0%)	1 (9%)	
Type of initial transplant			
Single lung	2 (50%)	2 (18%)	NS
Bilateral lung	2 (50%)	9 (81%)	
Initial transplant approach			
CS	1 (25%)	7 (64%)	NS
Anteroaxillary thoracotomy	1 (25%)	3 (27%)	
Posterolateral thoracotomy	2 (50%)	1 (9%)	
Ischaemic time			
First lung (min)	282 ± 25	324 ± 29	NS
Second lung (min)	432 ± 39	463 ± 35	NS
CBP use	3 (75%)	4 (36%)	NS
CBP time (min)	149 ± 18	280 ± 53	NS
Operative time (min)	609 ± 78	576 ± 30	NS

BAT: bilateral anteroaxillary thoracotomy; CS: clamshell; CF: cystic fibrosis; IPF: idiopathic pulmonary fibrosis; COPD: chronic obstructive pulmonary disease; CBP: cardiopulmonary bypass; NS: non-significant.

Statistical analysis

Fisher’s exact test and independent *t*-test were used for categorical and continuous variable analysis, respectively. Values are reported as means ± standard deviation. Actuarial survival was calculated using the Kaplan–Meier method (log-rank, *P* < 0.05).

RESULTS

Demographic and perioperative characteristics for the two groups are compared in Table 1. Both groups were similar with regard to age and primary transplant characteristics. There was a non-significant trend towards a higher frequency of cardiopulmonary bypass (CPB) in the BAT group compared with the CS group. However, the duration of CPB support was shorter in the BAT

Table 2: Comparison of postoperative outcomes of the control and study groups

Characteristic	BAT (n = 4)	CS (n = 11)	P-value
PGD requiring ECMO	1 (25%)	2 (18%)	NS
ICU LOS (days)	17 ± 3	35 ± 13	NS
Total LOS (days)	41 ± 4	64 ± 13	NS
Initial intubation time (h)	181 ± 214	319 ± 487	NS
3-month FEV ₁ increase (l)	1.1 ± 0.4	0.8 ± 0.2	NS
6-month FEV ₁ Increase (l)	1.2 ± 0.4	1.1 ± 0.3	NS
Operative mortality	0 (0%)	2 (18%)	NS

BAT: bilateral anteroaxillary thoracotomy; CS: clamshell; PGD: primary graft dysfunction; ECMO: extracorporeal membrane oxygenation; ICU: intensive care unit; LOS: length of stay; FEV₁: forced expiratory volume in 1 s; NS: non-significant.

group. The operative time was slightly longer in the BAT group, but this difference did not achieve statistical significance. With regard to postoperative outcomes (Table 2), both groups had a similar incidence of post-transplant primary graft dysfunction requiring extracorporeal membrane oxygenation support. There was no significant difference in the lengths of intensive care unit (ICU) and total hospital stay between the groups although the BAT group had a non-significant trend towards a shorter stay compared with the CS group. Interestingly, while not statistically significant, the CS group had an average duration of mechanical ventilation almost twice that of the BAT group (319 vs 181 h) and an FEV₁ improvement at 3 months of only two-thirds that of the BAT group (0.8 vs 1.1 l). Importantly, both groups experienced a similar improvement in FEV₁ at 6-month post-transplant. There were no operative mortalities in the BAT group. Two patients in the CS group died postoperatively, 1 from sepsis and multiorgan failure and the other from *Acinetobacter baumannii* pneumonia. There was no statistical difference between the groups with regard to 6-month survival (Fig. 2).

DISCUSSION

In this study, we demonstrate the feasibility of utilizing a sternal-sparing approach for patients undergoing reoperative lung

Figure 2: Kaplan-Meier curve comparing survival of the CS and BAT groups ($P = \text{NS}$).

transplantation. The preliminary data presented here suggest that this approach may result in equivalent outcomes with regard to survival, early allograft function, as well as ICU and total hospital stay. While the mean ICU and total hospital length of stays were shorter (by 18 and 23 days, respectively) in the sternal-sparing group, suggesting a potential benefit, the sample size was not sufficient to demonstrate a statistically significant difference. A similar trend was noticed with the duration of mechanical ventilation. We believe that this is the first report describing the feasibility of this approach for reoperative lung transplantation.

From the surgical perspective, this approach provides many technical challenges for the operating team. While excellent exposure to the hilar structures is afforded with the BAT approach, exposure to other areas such as the diaphragmatic and apical surfaces is certainly suboptimal compared with the CS approach, making dissection in those areas more challenging [2]. In our experience, most of the adhesions occur along the previous incision and therefore, entering in the lower rib space often allows for easier re-entry. The added time required for dissection should be accounted for when coordinating the donor cross-clamp time and initiation of the recipient operation.

Another significant technical challenge relates to dissection of the pulmonary artery from the bronchus, which are often densely adhered to each other. We have utilized a technique that involves obtaining intrapericardial control of the main pulmonary artery in order to maintain vascular control during this dissection. Alternatively, CPB may be initiated prior to hilar dissection to minimize the potential for pulmonary artery injury and catastrophic bleeding. Interestingly, CPB was required with greater frequency in the BAT group than the CS group. This is likely related to differences in recipients' pulmonary artery pressures and right ventricular function. However, it is also important to keep in mind that the closed sternum, in the setting of retraction of the heart, may result in haemodynamic embarrassment mandating the use of CPB. These aspects were not evaluated in this initial study, but would be important to evaluate as experience with this technique grows.

Our experience with the sternal-sparing BAT approach evolved out of a desire to maintain sternal integrity. Some centres [4, 5], including our own, believe that this approach has numerous potential advantages for the patient including (i) avoiding sternal wound-healing problems (i.e. dehiscence, infection etc.), (ii) superior respiratory mechanics (i.e. better pulmonary function) and (iii) hastening recovery (i.e. quicker extubation, ambulation and discharge). We have recently demonstrated that in the setting of primary lung transplantation, this approach results in quicker extubation and superior pulmonary function at 3- and 6-months post-transplant compared with the traditional CS approach [6]. In this study, we noticed a similar, albeit non-significant, trend using the BAT approach.

There are numerous, obvious limitations to this study that are typical of other small retrospective reviews. The most significant is the small sample size of both the BAT ($n = 4$) and CS groups ($n = 11$). The consecutive nature of the procedures with the last 4 patients having undergone the sternal-sparing BAT approach as a natural progression of technique makes selection bias a less concerning problem. Nonetheless, it is important to recognize that this approach represents a careful transition of surgical technique over a significant period (close to 5 years) with a large number of primary lung transplants. Consequently, the learning curve for this technique is expected to be steep and it would be our expectation that this approach would be more easily translatable at large volume lung transplant centres.

In conclusion, the data presented here suggest that a sternal-sparing approach for reoperative bilateral lung transplant is feasible and may yield outcomes similar to the traditional clamshell approach. While this early experience is encouraging, it is clearly limited by the small sample size (4 BAT and 11 CS patients), thus making it difficult to make firm conclusions regarding the superiority of one approach over the other. Further evaluation in larger numbers of patients is warranted to determine whether this approach can truly lead to equivalent or superior outcomes after reoperative bilateral lung transplantation.

Conflict of interest: none declared.

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