Bilateral sequential lung transplantation without sternal division

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Received 19 October 2002; received in revised form 10 February 2003; accepted 17 February 2003

Abstract

Objectives: The ‘clamshell incision’ is considered the standard approach for bilateral sequential lung transplantation (BSLT); however, a considerable morbidity may be related to this incision. The bilateral anterolateral thoracotomy without sternal division is an alternative approach that may contribute to avoid chest wall complications. Methods: We have employed this approach in a prospective series of 34 patients undergoing bilateral transplantation (Group I). The results were retrospectively compared with an historical control group of 37 patients (Group II) undergoing transplantation through the clamshell incision. Results: The operative time in Groups I and II were 228 ± 32 and 293 ± 37 min, respectively; the difference between the ischemic time of the first and second lungs were 68 ± 20 and 73 ± 15 min. Intensive care unit stay was 5 ± 6 vs. 13 ± 10 days and length of hospitalization was 25 ± 16 vs. 32 ± 10 days. Vital capacity measured 3 weeks after the transplant was significantly higher in Group I (65 ± 13 vs. 45 ± 8% predicted) as well as FEV1 (71 ± 8 vs. 58 ± 7% predicted). No wound related complication was observed in Group I; in Group II, there were 17 chest wall complications: sternal osteomyelitis in three patients (surgical debridement and closure with a muscle flap), migration of the Kirshner wire in three (removal of the wire), sternal override in three (surgical correction) and prolonged pain in eight. Conclusions: The bilateral anterolateral thoracotomy without sternal splitting is a safe and effective approach for BSLT; it allows to avoid sternal complications and contributes to improve respiratory function in the early postoperative period.

Keywords: Lung transplantation; Surgical approach; Clamshell incision

1. Introduction

Bilateral sequential lung transplantation (BSLT) [1] is actually considered the procedure of choice when both lungs have to be replaced; it has replaced worldwide the ‘en-bloc’ technique through median sternotomy [2] and it is usually performed with a trans-sternal bilateral anterolateral thoracotomy (‘clamshell incision’) [3]. The transverse sternothoracotomy allows extensive exposure of both pleural spaces and posterior mediastinum with expedite access to the great vessels for cardio-pulmonary by pass (CPBP). However, this excellent approach presents some drawbacks: the wide incision is objectively painful, even if epidural analgesia can improve tolerance; there is also a restriction in chest wall mechanics in the early postoperative period [4] and, additionally, there are a number of complications related to transverse sternotomy (infection, dehiscence, pseudoartrosis). The routine dissection of the anterior mediastinum and division of the mammary vessels can be an additional source of bleeding.

For these reasons, a less invasive approach has been proposed by Meyers [5] with two sequential anterolateral thoracotomies without sternal division; this approach seems to provide a suitable exposure to perform transplantation, avoiding the disadvantages related to sternal splitting [5,6].

We have evaluated the results obtained with this approach in a prospective series of patients receiving BSLT; this group of patients was retrospectively compared with an historical group receiving BSLT through transverse sternothoracotomy.

2. Patients and methods

From 1994 to 2002, we performed 71 BSLT. The first 37
patients (M/F: 17/20; mean age 29 ± 11 years; range 8–54 years) were operated on through a standard clamshell incision according to the technique previously described by Pasque et al. [1] (Fig. 1); since 1999, we have prospectively employed as a standard approach two separate sequential anterolateral thoracotomies without sternal division in 34 patients (Fig. 2) (M/F: 18/16; mean age 28 ± 10; range 15–23 years; Group I). The operative time, intraoperative events and postoperative results from this group were retrospectively compared with the historical group of patients receiving BSLT through the clamshell incision (Group II). All patients were included in the waiting list for lung transplantation according to the guidelines proposed by the International Society for Heart and Lung Transplantation [7]. Preoperative mean FEV₁ was 22 ± 5% predicted in Group I and 24 ± 6% in Group II. In Group I, 30 patients (88%) had cystic fibrosis, two (6%) emphysema, one (3%) bronchiectasis and one (3%) alveolar microlitiasis; in Group II, 26 patients (70%) had cystic fibrosis, four (11%) emphysema, four (11%) bronchiectasis, two (5%) idiopathic pulmonary fibrosis and one (3%) primary pulmonary hypertension. In Group I, nine patients (26.4%) previously received thoracic procedures (two lobectomies, five pneumonectomies, one unilateral lung volume reduction for emphysema and one double lung transplantation (DLT)).

Patients undergoing two separate thoracotomies without sternal division are placed on the operatory table in the supine position with the arms along the chest. Intraoperative monitoring is accomplished with full respiratory monitoring, one central line with continuous cardiac output monitoring, two arterial lines, electrocardiogram (EKG) and transesophageal echocardiography. Transplantation is started on the worse side based on preoperative computed tomography and ventilation/perfusion scan, with the table rotated towards the contralateral side. An anterolateral thoracotomy is performed in the fifth intercostal space without dividing the mammary vessels. If harvesting of the donor lungs require more time, the contralateral chest is also entered and the dissection of the hilum is started while waiting for the harvesting team (this was possible in 32 of the 34 patients receiving this approach). Lung transplantation is performed in the usual way with telescoping bronchial anastomosis [8] covered with mediastinal tissue, pulmonary artery and common atrial anastomosis. After implantation of the first lung, the retractor is removed and the operatory field is covered with a wet gauze without closing the chest. The table is rotated towards the other side, the dissection is completed and contralateral transplantation is performed in the same way. In case CPBP is required at any point, the mammary vessels are ligated and divided and the body of the sternum is transected at the level of the two anterolateral thoracotomies. The criteria for CPBP include desaturation and hemodynamic instability and are considered on a case-by-case basis. At the end of the procedure, hemostasis is ensured on both sides; if the donor lungs are too large to fit the recipient chest cavities, volume reduction is obtained performing multiple wedge resections with GIA staplers (Ethicon Inc. Somerville, NJ, USA) and bovine pericardium buttressing (Synovis, Minneapolis, MN, USA) (usually in the lingula, the middle lobe, the ventral segment of the upper lobes and the apical segment of the lower lobes).

The BSLT through the clamshell incision was performed according to the technique described by Pasque et al. [1]. The sternum is closed with two wires; one or two Kirshner wires are usually inserted inside the sternum bridging the two edges to prevent override.

Induction and maintenance of immunosuppression was the same in both groups (Cyclosporine A, Azathyprine, Steroids; the first four patients in Group II received induction of immunosuppression with rabbit ATG).

Data were expressed as mean ± standard deviation of n number of observations; comparisons between the two groups were made by the Student t test and χ² analysis. The a priori level of significance was at P < 0.05.
3. Results

Demographic data, preoperative functional parameters and diagnosis were not different between the two groups. The data concerning intra- and postoperative variables are reported in Table 1. Seven patients required volume reduction for size matching in Group I and eight in Group II (all patients had cystic fibrosis). In Group I, eight patients were extubated in the operatory room immediately after the transplant. Operative mortality was 17.6% (six patients) in Group I (infection, three; primary graft failure, two; myocardial infarction, 1) and 13.5% (five patients) in Group II (infection, three; primary graft failure, two). Spirometric measurements were usually performed between the third and fourth postoperative week; patients surviving less than 3 weeks (five and three in Groups I and II, respectively) or still on the ventilator (three and four in Groups I and II, respectively) at that time were not considered (eight and seven in Groups I and II, respectively); in Group I, five additional patients were excluded: they required CPBP and the approach was converted into a clamshell incision; three of these patients were alive but with a tracheostomy at the time of scheduled spirometry; the remaining two were excluded to keep Group II homogeneous. Thus, spirometry was performed in 21 patients in Group I and 30 in Group II. Postoperative vital capacity was significantly higher in Group I (65 ± 13 vs. 48 ± 8% predicted; P = 0.02) as well as FEV1 (71 ± 8 vs. 58 ± 7% predicted; P = 0.03). No wound or chest wall complications were observed in Group I. In Group II, there were nine major complications related to the surgical approach (24%): sternal osteomyelitis due to pseudomonas coepeca in three patients with cystic fibrosis (surgical debridement and closure with a muscle flap), migration of the Kirshner wire in three (removal of the wire), sternal override in three (surgical correction and fixation); eight patients experienced prolonged pain (22%; medical treatment). Postoperatively, patients with both approaches experienced a number of minor complications (acute rejection, infection, pericardial effusion, pneumothorax, seizures, arrhythmia) without any significant difference between the two groups. Bronchial complications occurred in six patients in Group I (17.6%) and seven patients (19%) in Group II (P > 0.05).

4. Discussion

The surgical technique for DLT underwent a number of modifications since it was first described by Patterson et al. in 1988 [3] and received incredible benefit from the progressive technical improvement; it can actually be performed with good operative results and reduced morbidity. The technique initially described by the group of Toronto came from heart–lung transplantation (HLT) and was performed with the patient on CPBP, routine cardiac arrest, extended dissection of the posterior mediastinum and a single tracheal, pulmonary artery and common atrial anastomosis. This operation, although clinically feasible, was technically difficult and carried a number of complications related to the surgical technique itself: bleeding, heart failure and primary graft failure; furthermore, the interruption of the bronchial circulation had an impact on tracheal healing resulting in an increased incidence of airway problems [9]. For this reason, several modifications have been subsequently proposed. Noirclerc et al. [10] described the feasibility of bilateral bronchial anastomosis instead of tracheal anastomosis both for DLT and HLT. The potential role for bronchial artery revascularization was investigated [11–14]; however, the technical complexity of lung harvesting and transplantation prevented its wide-spread application. Eventually, Pasque and colleagues [1] described the technique of BSLT that progressively became the procedure of choice when both lungs have to be transplanted. According to this technique, two separate single lung transplants are performed in sequence through a clamshell incision. This innovation has been an important step ahead to simplify the surgical technique and reduce surgical morbidity and mortality. This approach allows an excellent view of both pleural cavities, from the apex to the diaphragm, pulmonary hila and posterior mediastinum; CPBP is not routinely employed, but when required it can be safely instituted since the anterior mediastinum has already been dissected and the great vessels can be quickly prepared. However, the clamshell incision may be associated to a significant morbidity [4], as we also experienced and described in our retrospective control group. Sternal stabilization can be improved with the insertion of one or two Kirshner wires and also other devices have been employed [15]; however, chest wall complications are still a potential major challenge. For this reason, it has been proposed a less invasive surgical approach able to solve completely the problems related to transection of the sternum [3,6], with the same operative results and reduced morbidity. The bilateral anterolateral thoracotomy avoids sternal splitting, legation of the internal mammary vessels and dissection of the anterior mediastinum. The two separate anterolateral thoracotomies can be easily converted.
into a clamshell incision if CPBP is required; however, it has been recently reported that CPBP can be safely instituted without splitting the sternum by transcutaneous extra corporeal cannulation [16]; also cannulation of the femoral vessels could be considered to avoid conversion to the standard ‘old fashion’ sternothoracotomy and we are now moving in this direction. With this approach, it is possible to perform BSLT also in patients previously undergone major thoracic operations, including lobectomy, lung volume reduction and transplantation; diffuse pleural adhesions can be safely coagulated and divided. When compared to the retrospective control group, the operative time was slightly shorter, probably due to the easier closure of the chest; the difference between the ischemic time of the first and second lung was not statistically significant between the two groups. In Group I, eight patients could be extubated in the operatory room and the intensive care unit (ICU) stay was significantly reduced; however, this is probably related to a more liberal policy now followed at our center after many years of experience with lung transplantation. Pain control and this functional parameters in the early postoperative period were improved with a better vital capacity and FEV1, and this is certainly contributes to improve respiratory function in the early postoperative course.

**References**