MEDICAL SCIENCE MONITOR BASIC RESEARCH

HUMAN STUDY

eISSN 2325-4416
© Med Sci Monit Basic Res, 2015; 21: 222-225
DOI: 10.12659/MSMBR.895419

Received: 2015.07.22
Accepted: 2015.09.20
Published: 2015.10.12

When the Battle is Lost and Won: Delayed Chest Closure After Bilateral Lung Transplantation

Authors' Contribution:
Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
Funds Collection G

ABCDEFG Simona Soresi
ABCDEFG Anton Sabashnikov
ABCDEFG Alexander Weymann
ABCDEFG Mohamed Zeriouh
ABCDEFG André R. Simon
ABCDEFG Aron-Frederik Popov

Department of Cardiothoracic Transplantation and Mechanical Circulatory Support, Royal Brompton & Harefield NHS Foundation Trust, Harefield Hospital, Harefield, Middlesex, London, U.K.

Corresponding Author: Anton Sabashnikov, e-mail: a.sabashnikov@gmail.com
Source of support: Departmental sources

In this article we summarize benefits of delayed chest closure strategy in lung transplantation, addressing indications, different surgical techniques, and additional perioperative treatment. Delayed chest closure seems to be a valuable and safe strategy in managing patients with various conditions after lung transplantation, such as instable hemodynamics, need for high respiratory pressures, coagulopathy, and size mismatch. Therefore, this approach should be considered in lung transplant centers to give patients time to recover before the chest is closed.

MeSH Keywords: **Lung Transplantation • Operative Time • Surgery Department, Hospital**

Abbreviations: **BOS** – bronchiolitis obliterans syndrome; **DCC** – delayed chest closure; **ECMO** – extracorporeal membrane oxygenation; **EVLP** – *ex vivo* lung perfusion; **LT** – lung transplantation; **PCC** – primary chest closure; **PGD** – primary graft dysfunction

Full-text PDF: http://www.basic.medscimonit.com/abstract/index/idArt/895419

1538 1 1 7

Indexed in: [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS] [Index Copernicus]

Background

Lung transplantation (LT) is an established treatment for end-stage respiratory failure not responding to conventional medical treatment [1]. Transplant surgeons now have more challenging cases due to the extension of donor criteria, more common use of extracorporeal membrane oxygenation (ECMO) support as a bridge to LT, and perform redo procedures following development of bronchiolitis obliterans syndrome (BOS). Due to recent advances in organ preservation technology, further organ assessment and optimization options, such as the organ care system (OCS) and the *ex vivo* lung perfusion (EVLP), have become available and are successfully implemented in clinical practice. However, surgeons are still left with few options in cases of unstable patients at the time of the surgery. After maximizing the medical therapy, the next step is inevitably a transition to an ECMO, with potentially serious complications [2].

The concept of "open chest" as a therapeutic manoeuvre for patients who are hemodynamically unstable after LT (Figure 1) is supported by extensive experience from cardiac surgery and, more recently, from ventricular assist device (VAD) implantation [3]. Limited data from retrospective studies are available to compare short- and longer-term outcomes from lung transplant recipients using the open chest management technique as opposed to the conventional primary chest closure (PCC). We review these results with particular focus on establishing indications and clear protocols for management of patients potentially suitable for delayed chest closure (DCC) following LT.

Literature Review

The first case series on DCC patients following LT was published in 2006 by Force et al. [4]. It was a retrospective study including 28 patients undergoing LT. Seven patients were in the DCC group whereas the remaining 21 patients in the PCC group were considered controls. Patients were compared in terms of demographic characteristics and pre- and post-operative variables. They showed that DCC compared with PCC is associated with significantly higher transfusion requirements, higher pulmonary artery pressure, use and duration of CPB, ischemic time, and lower pO2/FiO2 ratio (Table 1). The transplant surgeons left the chest open in several cases based on hemodynamic and respiratory problems during closure attempts. The open chest was covered using a double layer of latex-free Esmark bandaging (Fulflex Elastomerics Worldwide, Lincoln, RI, USA), attached to the skin using non-absorbable sutures and an additional coverage using an Ioban drape (3M, St. Paul, MN, USA). A rib spreader was used for active sternal retraction in just 1 patient. The authors reported the mean time to final closure as 5.3 days. Patients in the DCC group had significantly higher incidence of tracheostomy (p=0.003) and prolonged

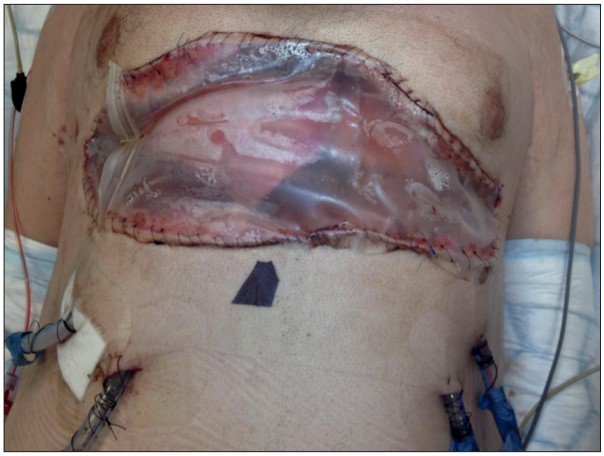

Figure 1. Delayed chest closure after bilateral lung transplantation. Superficial structures, including fascia, subcutaneous tissue, and skin, are left open and the ribs are not approximated. A transparent membrane is used to cover the thoracic space.

hospital stay (p=0.030), but not affecting survival at 1 month, which was 100% in both groups. No evidence of wound infections was reported in either group. Patients in the DCC group had a significantly higher incidence of PGD (n=5, 71.4%), but this was not associated with increased mortality as previous data reported [5]. The authors justified significant graft dysfunction with the high-risk factors of the patients transplanted, such as primary diagnosis of Eisenmenger's syndrome, sarcoidosis with pulmonary hypertension, complex pleural spaces, and high ventilator dependence at the time of transplantation. Moreover, they speculated that delayed chest closure may be an important alternative surgical strategy for patients with signs of PGD.

Similar results were reported by D'Cunha et al. in their review of the LT database from the University of Minnesota [6]. From October 2006 to February 2008, 5 patients had DCC. Patients presenting with respiratory and/or hemodynamic instability noted at attempts to close the chest intraoperatively had a temporary closure of the chest using the Esmarch (Cardinal Health, Dublin, OH, USA) dressing. The mean length of open chest splinting was 5.4 days (range, 4–9 days). The decision to close the chest was made using the following criteria: CVP <10 mm Hg and acceptably low hemodynamic support. Survival at 1 month was 100% and all the patients were discharged home after a mean hospital stay of 41 days (range, 26–62 days). The authors' conclusions were in favor of DCC as a way to avoid ECMO support in unstable patients perioperatively. They stressed the importance of using a specific protocol for these patients to maximize outcomes with specific consideration and focus on fluid management, ventilatory protective strategies, and appropriate antibiotic therapy.

Indexed in: [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica]
[Chemical Abstracts/CAS] [Index Copernicus]

Table 1. Variables associated with delayed chest closure (Force SD, Miller, DL, Pelaez A et al: Outcomes of delayed chest closure after bilateral lung transplantation. Ann Thorac Surg, 2006; 81: 2020–25).

	PCC (n=21)	DCC (n=7)	p-value
Transfusion requirements (RBC)	2.7	12.1	<0.01
Systolic PAP (mm Hg)	43.6	71.3	0.03
Use of CPB	8 (38%)	7 (100%)	<0.01
CPB (minutes)	184	270	<0.01
Ischemic time 1st lung (minutes)	245.3	337.1	0.04
Ischemic time 2nd lung (minutes)	299.2	407.1	0.01
Ischemic time	272.2	373.2	<0.01

RBC – red blood cells; PAP – pulmonary artery pressure; CPB – cardio-pulmonary bypass.

The largest series of DCC patients was reported from Shigemura et al. [7] from the University Pittsburgh Medical Center. A total of 873 patients received LT from January 2004 to December 2011; 90 patients (10.3%) had DCC. Surgeon decision to leave the chest open was based on hemodynamic stability, coagulopathy status, lung graft function/compliance, or size-matching of lung grafts. The outcomes were then compared between the 2 groups (DCC *vs.* PCC). A subgroup analysis was made considering 3 different techniques used to leave the chest open, depending on the size of the lung allografts and patient hemodynamics: (1) superficial structures, including skin and subcutaneous tissues, were closed but the ribs were left unapproximated; (2) superficial structures were left open and covered with a medical bandage (Esmark, Medical Industries, Inc., Mundelein, IL, USA), and the ribs were left unapproximated; (3) superficial structures were left open and a chest retractor was used to keep the ribs open. However, the authors failed to provide information about the baseline characteristic of the patients in each group. Knowing the comorbidities and severity of their disease would help to explain the postoperative outcome for each surgical technique. Interestingly, significantly higher incidence of previous coronary artery disease, higher pulmonary artery pressure, higher lung allocation score (LAS), and higher incidence of ECMO prior to transplant were noted in the DCC group. The results from this study in terms of postoperative outcomes also showed a higher incidence of severe PGD requiring post-operative ECMO support (12% *vs.* 9.4%, p=0.05). The incidence of renal insufficiency and dialysis was also higher in the DCC group (7.8% *vs.* 2.3%, p=0.05). In addition, the incidence of postoperative bleeding requiring reexploration was significantly higher in the DCC group. Moreover, 30- and 90-day mortality were higher in patients with DCC (7.8% *vs.* 2.7% and 9.9% *vs.* 3.7%, respectively; p=0.05). Survival at 5 years after LT was worse in patients with DCC (43.1%) than in patients with primary chest closure (58.9%).

Subgroup analysis considering the 3 different techniques showed that the 8 patients who underwent DCC with open skin and retracted ribs had the highest incidence of severe PGD, re-exploration for bleeding, and respiratory and renal complications after surgery. They also had significantly worse peak FEV1 and 6-min walk test values, indicating worse allograft function. Patients who had DCC with the "open skin and un-approximated ribs technique" had higher incidence of bleeding, severe PGD, renal insufficiency, and respiratory complications after LT compared with patients who underwent primary chest closure, but they had similar peak allograft function. Finally, when the "skin closed and un-approximated ribs technique" was used, a higher incidence of re-exploration and severe PGD was found compared to the PCC group patients (p=0.05). However, the important finding was that the DCC group experienced no significant differences in terms of respiratory complications or peak allograft function. In addition, the incidence of empyema, septicemia, and mortality was similar to the primary chest closure group. The authors concluded that appropriate DCC techniques and particularly careful post-DCC management can reduce PGD due to the lack of additional mechanical insult to the transplanted lungs in patients with already higher risk of PGD, and may also reduce the risk of infection.

Discussion

DCC in patients with significant cardiopulmonary edema is associated with several benefits compared to primary chest closure, particularly reduced respiratory and hemodynamic deterioration, caused by compression. The common indications for DCC are acute lung edema, oversize allograft, coagulopathy/bleeding requiring several blood transfusions, hemodynamic instability, or impaired PaO2/FiO2 ratio [4,6,7].

Indexed in: [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica]
[Chemical Abstracts/CAS] [Index Copernicus]

The effectiveness of DCC use seems to be enhanced by correct post-operative management of the patients, with strict adherence to protocol-driven care. In particular, attention should be placed on fluid management, protective ventilation, and broad-spectrum antibiotic treatment. To reduce lung edema, it has been proposed to optimize urine output to a CVP level of 10 mm Hg. This strategy was successful in closing the chest in all patients in all the series. Significant renal dysfunction and suboptimal diuresis considering early mechanical hemofiltration would certainly reduce the time to chest closure. In terms of using "protective ventilatory strategies" low tidal volume ventilation has been reported and was suggested to improve outcomes and minimize duration of mechanical ventilation in this setting [7].

Finally, optimization of antibiotic treatment and the use of broad-spectrum antibiotics are paramount in order to limit the risk of chest infection and empyema. When the chest is left open, a routine chest washout 2 to 4 days after LT and topical antibiotics for irrigations should be performed. Regular cultures should be sent for microbiologic evaluation to target antibiotic treatment.

Conclusions

In summary, DCC is a valuable and safe strategy in managing patients with various conditions after LT. In cases when closing the chest remains questionable in terms of hemodynamics, ventilation, and coagulopathy status, this approach should be considered in order to give the patient time to recover from perioperative trauma. However, research is lacking on this important topic, and further clinical trials are needed to confirm these preliminary results.

Disclosure

The authors declare no conflicts of interest.

References:

1. Christie JD, Edwards LB, Kucheryavaya AY et al: The registry of the International Society for Heart and Lung Transplantation: 29th adult lung and heart-lung transplant report – 2012. J Heart Lung Transplant, 2012; 31: 1073–86
2. Diamond JM, Lee JC, Kawut SM et al: Clinical risk factors for primary graft dysfunction after lung transplantation. Am J Respir Crit Care Med, 2013; 187: 527–34
3. Stulak JM, Romans T, Cowger J et al: Delayed sternal closure does not increase late infection risk in patients undergoing left ventricular assist device implantation. J Heart Lung Transplant, 2012; 31: 1115–19
4. Force SD, Miller DL, Pelaez A et al: Outcomes of delayed chest closure after bilateral lung transplantation. Ann Thorac Surg, 2006; 81: 2020–25
5. Dahlberg PS, Prekker ME, Herrington CS et al: Medium term results of extracorporeal membrane oxygenation for severe acute lung injury after lung transplantation. J Heart Lung Transpl, 2004; 23: 979–84
6. D'Cunha J, Rueth NM, Belew B et al: The effectiveness of the "open chest" for the unstable patient after bilateral sequential lung transplantation. J Heart Lung Transplant, 2010; 29: 894–97
7. Shigemura N, Orhan Y, Bhama JK et al: Delayed chest closure after lung transplantation: Techniques, outcomes, and strategies. J Heart Lung Transplant, 2014; 33: 741–48

Indexed in: [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS] [Index Copernicus]