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Moving Back to the Future: Use of Organ Care System Lung for Lobectomy Before Lobar Lung Transplantation

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Background: Lung transplantation remains the gold standard treatment for patients with end-stage lung disease. Lobar lung transplantation allows for transplantation of size-mismatch donor lungs in small recipients; however, donor lung volume reduction represents a challenging surgical technique. In this paper we present our initial experience with bilateral lobectomy in donor lungs before lobar lung transplantation using normothermic perfusion on the Organ Care System (OCS) Lung.

Material/Methods: Specifics of the surgical technique for donor lung instrumentation on the OCS, lobar dissection on the OCS, and right and left donor lobectomies are presented in detail.

Results: Potential advantages of the use of the OCS for lobectomy for lobar lung transplantation are described in this section. Donor lung volume reduction utilizing OCS appeared to be easier and safer compared to the conventional cold storage technique, due to continuous perfusion of the lungs with blood and well-distended vessels that offer the feel of live lobectomy. Moreover, the OCS represents a platform for donor organ assessment and optimization of its function before transplantation.

Conclusions: Donor lung volume reduction was safe and feasible utilizing the OCS, which could be a useful tool for volume reduction in cases of size mismatch. Further research is needed to evaluate early and long-term results after lobar lung transplantation using the OCS in clinical studies.

MeSH Keywords: Acute Lung Injury • Cardiac Electrophysiology • Heart-Lung Transplantation

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Background

Lobar lung transplantation represents one of the tools to enable transplantation in small-sized recipients, expanding the donor pool for this patient cohort. Early experience with the portable Organ Care System (OCS) Lung device for concomitant preservation, assessment, and transportation of donor lungs showed that it provides a safe platform for lung preservation using normothermic perfusion [1]. The OCS allows perfusion and ventilation of the donor lungs under practically physiological conditions [2].

A prospective, randomized multicenter trial, INSPIRE, was started in November 2011, to compare preservation using OCS Lung with standard cold storage. However, there have been limited data on feasibility and safety of performing lung reduction surgery on OCS after such preservation and transportation. In this paper, we present our technique for a successful utilization of OCS Lung for bilateral lobectomy before lobar lung transplantation in patients with reduced total lung volumes.

Material and Methods

Implantation technique

Patients were anaesthetized and prepared for surgery, including a dual lumen endotracheal tube to allow for single lung ventilation. Hemodynamics, cardiac output, and pulmonary artery pressure were monitored using Swan-Ganz thermodilution catheter and transesophageal echocardiography. Lung implantation was usually performed on the right side first. Note that the operation can be performed through standard clamshell incision or through minimally invasive surgical access using bilateral thoracotomies, as described in detail elsewhere [3]. Following identification of the phrenic nerve, the pulmonary artery was circumnavigated and occluded as soon as possible, with a view to enabling sufficient time for assessment of right heart function, gas exchange, and lung mechanics during further dissection. At this point, single lung ventilation with nitric oxide was commenced as a right heart protective measure. Dependent on patients' hemodynamic stability, the decision was made whether to commence cardio-pulmonary bypass (CPB).

Organ procurement

In terms of organ procurement, the operation was performed in the usual way with minor differences used at our center. The standard preservation solution Perfadex (Medisan, Uppsala, Sweden) augmented with CaCl2, 3.6% tromethamine (THAM, Hospira Inc, Lake Forest, IL, USA), and epoprostenol sodium 2.5 mL/L was administered antegradely (3 L) in donors after cardiac death (DCD) or 4 L in donors after brain death (DBD) through a Medtronic 24 Fr single stage venous cannula into the pulmonary artery; retrograde perfusion (2 L in DCD and 1 L in DBD) was performed either *in situ* or on the back table after organ resection using a Medtronic 15 Fr retrograde cannula with a self-inflating balloon. Compared to standard preservation on ice, an additional 50 mg of glyceryl trinitrate (GTN) was added to the first bag of preservation solution. Before final acceptance, the lungs were inspected, palpated, and recruited. Particularly, trauma-related findings, such as moderate or severe air leak leading to an insufficient lung recruitment, or leakage of the preservation solution in the lung parenchyma, represented relative contraindications for the use of OCS. Furthermore, particular attention was paid to the functional and bronchoscopy status and general appearance of lower lobes, which are usually used for lobar transplantation due to their better anatomical configuration. In general, a lower function threshold for declining organs should be considered, according to poorer results after lobar lung transplantation-reported previously [4].

Instrumentation and transport on Organ Care System Lung

The system was set up using the standardized protocol and primed with 1.25 L buffered Perfadex solution and 775 mL leukocyte-reduced packed red blood cells. Additional drug additives included 500 mg methylprednisolone, 1 unit vial multivitamins, 20 units insulin, 4 mg milrinone, 40 mEq $NaHCO_3$, 10,000 units heparin, 1 g cefuroxime, 200 mg ciprofloxacin, and 200 mg voriconazole. The perfusate was warmed to 32°C. Once the target temperature was reached, a baseline blood gas test was performed.

The lungs were instrumented into the OCS via the connection of the pulmonary artery and trachea. Note that alternatively, in some cases of heart and lung procurement or anatomically short main pulmonary trunk, an additional piece of thoracic descending aorta can be anastomosed to the main pulmonary trunk in order to achieve appropriate length sufficient for connection. The perfusate flow was gradually increased and maintained between 1.5 and 2 L per minute, whereas the pulmonary artery pressure was monitored, as it should not exceed 20 mmHg. The temperature was set to 37°C; once it reached 34°C, lung ventilation was initiated. The preservation mode's ventilator settings were usually set to maintain a positive end expiratory pressure (PEEP) of 5 cm H_20 and a tidal volume (V_T) of 6 mL/kg of donor ideal body weight at a respiratory rate (RR) of 10 breaths per minute. After 10 minutes of stabilization at 37°C, baseline monitoring was initiated. During the monitoring phase, the pulmonary flow was set to 2 to 3 L/minute, and the ventilator settings were adjusted to achieve a PEEP of 7 cm H_20 and a V_T of 6 mL/kg of donor ideal body weight at a RR of 12 breaths per minute. Sequential

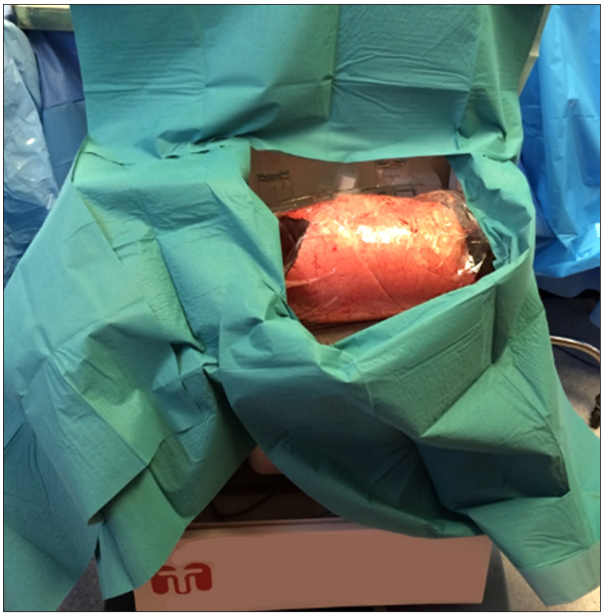

Figure 1. The entire dissection was performed during normothermic perfusion on the OCS in the back of the surgical theater.

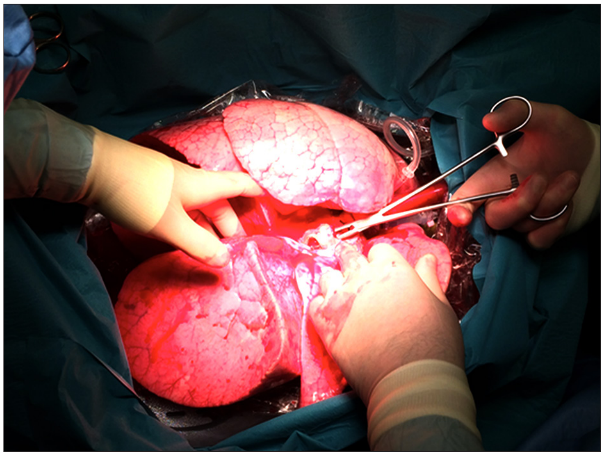

Figure 2. Normothermic perfusion of the lungs using OCS allowed for a more precise and technically easier bilateral lobectomy, as the vessels were clearly visible due to the red blood cell solution circulating through pulmonary vessels.

re-oxygenation time was measured and the pO_2/FiO_2 ratio calculated. Note that sequential re-oxygenation tests are an additional tool for assessment of lung performance and measure time required to increase the blood saturation from 73% to 93% with ambient air ventilation of donor lungs. The OCS was then set back to preservation mode and the monitoring assessment was then repeated during the final assessment before deciding whether the lungs were suitable for transplantation, and before transferring the recipient to the surgical theatre. The pO_2/FiO_2 calculation and re-oxygenation time were again repeated 30 minutes prior to dissection of the lungs on the OCS. A bronchoscopy was performed during transportation of lungs on OCS, as needed, in order to recruit any atelectatic area and optimize lung ventilation.

Lobar dissection on the OCS Lung

The technical aspects of the right and left donor lobectomies do not significantly differ from the techniques described previously for the back table [5]. However, a final flush sequence, which is usually initiated using 3 L of buffered Perfadex solution with an additional 50 mg of GTN administered into the first bag, was not performed, and the lungs were initially not disconnected from the system. The entire dissection was performed during normothermic perfusion on the OCS (Figure 1). That allowed for a more precise and technically easier bilateral lobectomy, as the vessels were clearly visible due to the red blood cell solution circulating through pulmonary vessels (Figure 2). We preferred using the lower lobes to avoid leaving bronchial stumps that could dehisce at a later stage. Also, in cases of planned major size mismatch, the vascular and bronchial structures of the lower lobes seemed to provide a perfect match in diameter with those of the recipients. As the lung block was kept fixed in position in the perfusion chamber, it allowed for an easier dissection. The fissures were dissected and the vascular branches encountered along the way were only circumnavigated at this stage and not ligated until after the final dose of Perfadex had been administered. Likewise, the lobar bronchi were identified and prepared, but kept intact until after the final preservation had been administered. This allowed for the OCS to continue working in a standard fashion without the need for adjustment of flow and ventilation to an otherwise estimated target.

Right upper and middle bilobectomy was completed through the major fissure, whereas the upper and middle lobes were removed, preserving the interlobar artery (Figure 3) and the distal bronchus intermedius that is usually stapled to avoid immediate deflation. The lower pulmonary vein with a small left atrial cuff was also dissected and used for further implantation (Figure 4). Similarly to this, during left upper lobectomy, the interlobar artery was preserved and the lower lobe bronchus was divided, whereas the lower pulmonary vein was preserved with a small left atrial cuff.

In order to shorten ischemic time, donor lobectomies can be also performed sequentially and before each implantation, so that while the first lower lobe is implanted into the recipient, the second lung remains perfused with normothermic solution and ventilated on the OCS. The implantation can then be performed in a usual way, as described previously [5,6].

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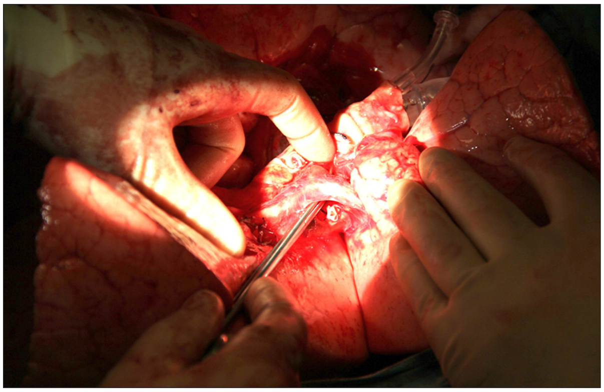

Figure 3. Right upper and middle bilobectomy completed through the major fissure, whereas the upper and middle lobes were removed, preserving the interlobar artery and the distal bronchus intermedius that is usually stapled to avoid immediate deflation.

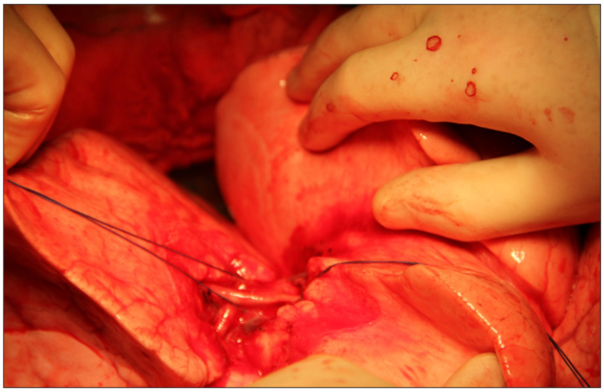

Figure 4. Lower pulmonary veins with a small left atrial cuff were dissected and used for further implantation.

Discussion

A number of strategies to expand the donor pool have been used in the current era of donor organ scarcity [7-10]. There are several conditions that may lead to the indication for a lobar lung transplant, such as small-sized patients with cystic fibrosis [11], other pediatric and small adult recipients [12], and patients just challenged by clinical course deterioration who cannot wait for a suitable donor size-match [13]. Recent evidence suggests that this type of transplantation is safe and feasible, as both short- and long-term outcomes are, in general, comparable with those of standard bilateral lung transplantation [14]. Time spent on the waiting list due to graft size incompatibility issues can often be prolonged and detrimental for pediatric patients and small adults in urgent need of transplantation [15]. The use of lobar transplantation and other size reduction techniques has allowed larger donor lungs to be utilized for smaller recipients, who tend to have longer waiting times for transplantation [16].

A back table lobectomy technique can be performed by a second surgeon, potentially decreasing the ischemia time, and is also useful in patients with a small chest cavity in which whole donor lung would obscure the view of the hilum. However, it may be technically difficult, as none of the vessels are distended by blood and all the structures appear white, making it difficult to identify and separate veins from arteries [16]. With OCS, due to continuous perfusion of the lungs with blood, the vessels are well distended, which offers the feel of a live lobectomy. The planes are clear as lungs are ventilated and well inflated. The ventilation can be stopped at crucial stages of dissection. Also, as mentioned above, the donor lung block is kept fixed and perfused with normothermic solution, making the dissection more comfortable and therefore easier and safer, while faster, too.

One of the further advantages of using OCS for bilateral lobar transplantation is shorter ischemic time, as the second lung can be perfused with normothermic solution and ventilated during implantation of the contralateral lower lobe. This is particularly important, as the results from a large cohort of patients published by Thabut et al. showed a close relationship between graft ischemic time and both early gas exchange and long-term survival after single and double lung transplantation [17]. Particularly, lung rewarming on the back table may have a detrimental impact on the post-transplant lung function, as the lobar implantation takes longer than a standard lung transplantation. Furthermore, as the technical aspects and quality of this operation are extremely demanding, less stress to the surgeon represents one of the key factors for achieving optimal results.

A recent report described a similar technique for downsizing of a lung graft on *ex-vivo* lung perfusion (EVLP) [18]. Compared to lobectomy on EVLP, the advantage of our method is that we used a portable system, which reduces the ischemic time further [19].

To our knowledge this is the first technical report on using the portable OCS Lung for lobar transplantation. Donor lung volume reduction utilizing OCS is feasible, and appears to be easier, more comfortable, and therefore safer compared to a conventional cold storage technique.

Conclusions

Donor lung volume reduction is safe and feasible utilizing OCS. The OCS could be a useful tool for volume reduction in cases of size mismatch.

Statement

All authors declare no conflict of interest, and freedom of investigation.

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References:

1. Warnecke G, Moradiellos J, Tudorache I et al: Normothermic perfusion of donor lungs for preservation and assessment with the Organ Care System Lung before bilateral transplantation: A pilot study of 12 patients. Lancet, 2012; 380(9856): 1851–58
2. Popov AF, Garcia Saez D, Sabashnikov A et al: Utilization of the organ care system – a game-changer in combating donor organ shortage. Med Sci Monit Basic Res, 2015; 21: 29–32
3. Fischer S, Struber M, Simon AR et al: Video-assisted minimally invasive approach in clinical bilateral lung transplantation. J Thorac Cardiovasc Surg, 2001; 122(6): 1196–98
4. Egan TM, Detterbeck FC, Mill MR et al: Long term results of lung transplantation for cystic fibrosis. Eur J Cardiothoracic Surg, 2002; 22(4): 602–9
5. Marasco SF, Than S, Keating D et al: Cadaveric lobar lung transplantation: technical aspects. Ann Thorac Surg, 2012; 93(6): 1836–42
6. Deuse T, Sill B, von Samson P et al: Surgical technique of lower lobe lung transplantation. Ann Thorac Surg, 2011; 92(2): e39–42
7. Wald A, Deterding L, Maier M et al: Hepatitis B Vaccination in end-stage pulmonary disease patients evaluated for lung transplantation: A retrospective single-center evaluation. Ann Transplant, 2016; 21: 368–72
8. Zych B, Garcia Saez D, Sabashnikov A et al: Lung transplantation from donors outside standard acceptability criteria – are they really marginal? Transpl Int, 2014; 27(11): 1183–91
9. Sabashnikov A, Patil NP, Popov AF et al: Long-term results after lung transplantation using organs from circulatory death donors: A propensity score-matched analysis. Eur J Cardiothorac Surg, 2016; 49(1): 46–53
10. Sabashnikov A, Patil NP, Mohite PN et al: Influence of donor smoking on midterm outcomes after lung transplantation. Ann Thorac Surg, 2014; 97(3): 1015–21
11. Stanzi A, Decaluwe H, Coosemans W et al: Lobar lung transplantation from deceased donors: A valid option for small-sized patients with cystic fibrosis. Transplant Proc, 2014; 46(9): 3154–59
12. Slama A, Ghanim B, Klikovits T et al: Lobar lung transplantation – is it comparable with standard lung transplantation? Transpl Int, 2014; 27(9): 909–16
13. Shigemura N, Bhama J, Bermudez C, D'Cunha J: Lobar lung transplantation: Emerging evidence for a viable option. Semin Thorac Cardiovasc Surg, 2013; 25(2): 95–96
14. Inci I, Schuurmans MM, Kestenholz P et al: Long-term outcomes of bilateral lobar lung transplantation. Eur J Cardiothorac Surg, 2013; 43(6): 1220–25
15. Sweet SC: Pediatric living donor lobar lung transplantation. Pediatr Transplant, 2006; 10(7): 861–68
16. Aigner C, Mazhar S, Jaksch P et al: Lobar transplantation, split lung transplantation and peripheral segmental resection – reliable procedures for downsizing donor lungs. Eur J Cardiothorac Surg, 2004; 25(2): 179–83
17. Thabut G, Mal H, Cerrina J et al: Graft ischemic time and outcome of lung transplantation: A multicenter analysis. Am J Respir Crit Care Med, 2005; 171(7): 786–91
18. Nosotti M, Rosso L, Mendogni P et al: Graft downsizing during *ex vivo* lung perfusion: Case report and technical notes. Transplant Proc, 2014; 46(7): 2354–56
19. Popov AF, Sabashnikov A, Patil NP et al: *Ex vivo* lung perfusion – state of the art in lung donor pool expansion. Med Sci Monit Basic Res, 2015; 21: 9–14

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