



## Normothermic *Ex-Vivo* Lung Perfusion (Evlp) Requiring Pulmonary Artery (Pa) Reconstruction after its Main Trunk Accidental Division during Harvesting

Filippo Antonacci<sup>o</sup>, Giampiero Dolci<sup>o</sup>, Francesca Calabrese, Elena Salvaterra, Niccolò Daddi, Jury Brandolini, Pietro Bertoglio, Piergiorgio Solli<sup>o</sup>

Department of Cardio-Thoracic Surgery, Irccs Azienda Ospedaliera Universitaria Di Bologna, Policlinico S. Orsola, Bologna, Italy

(<sup>o</sup> FA, GD & PGS equally contributed to the development of the manuscript)

**\*Corresponding author:** Filippo Antonacci, Division of Cardio-Thoracic Surgery, IRCCS Az. Ospedaliera Universitaria di Bologna, Policlinico S. Orsola-Malpighi, Bologna, Italy

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### Abstract

Normothermic *ex-vivo* lung perfusion (EVLP) is an established strategy to increase donor pool, improving graft quality assessment, facilitating self-repair mechanisms, providing a platform for active drug treatments and safely prolonging the preservation time. We report a case of a successful EVLP after retrieval in a 29-year-old donor deceased of car accident with associated chest trauma. During harvesting with cardiac surgeons, the main pulmonary artery (PA) trunk was accidentally divided leaving right and left branches disconnected, posing a crucial issue for EVLP cannulation. After damage assessment, in order to connect the graft to the PA cuff of the EVLP system, an original strategy was used for main PA reconstruction that is described in detail. After reconditioning, lungs were considered suitable and a bilateral lung transplant was carried out on a 48-years-old recipient affected by primary pulmonary hypertension. Postoperative period was uneventful, patient was discharged on 51st postoperative day and is well after more than 1 year of follow up. EVLP is a well standardized technique but requires intact vessels and airways. Precise levels of division of main PA trunk and left atrial cuff during harvesting are critical manoeuvres which may incidentally result in PA injury or short vein stumps. Additional care should be taken when the EVLP process is planned. This article highlights successful EVLP reconditioning and lung transplantation, despite PA division during retrieval, reporting a technical detail to restore an adequate arterial length in order to overcome lack of tissue when connecting PA to the cannula.

**Keywords:** EVLP; Lung Transplantation

**Abbreviations:** EVLP: *Ex-Vivo* Lung Perfusion; PA: Pulmonary Artery; P/F Ratio: PaO<sub>2</sub>/FiO<sub>2</sub> Ratio; ECMO: Extra Corporeal Membrane Oxygenation; cDCD: Controlled Or UdcD Uncontrolled Cardiac Death

### Introduction

Lung transplantation has definitely been recognized as the treatment of choice for end-stage lung diseases [1]. However, the shortage of suitable donors that largely exceeds the available supply continues to be a major challenge and as a result of such a disproportion, many potential recipients became too sick to undergo transplantation or alternatively die each year whilst in the waiting list. These data become crucial for lung transplantation,

due to a very low rate (15-35%) of suitable lungs amongst an overall low number of multi-organ brain death donors [2,3] and by a wait-list mortality as high as 30-40% according to historical series [4].

In recent years, a considerable advancement has been represented by the introduction of the *ex vivo* lung perfusion (EVLP) techniques. EVLP stands as an alternative to conventional approaches for donor lung assessment, reconditioning, and preservation, offering the chance to select lungs suitable for transplantation when evaluating lungs of “marginal” quality or from donors with “extended” criteria. The great utility of EVLP has been widely documented [5-8] and also has been confirmed its ability to increase the transplantable lung pool from 15% to 20% [9-11].

General indications for EVLP are low oxygenation rates ( $\text{PaO}_2/\text{FiO}_2 < 300$  mm Hg), signs of edema and poor compliance during procurement at lung examination, suspected previous history for aspiration, pneumonia of contra-lateral donor lung, and controlled donors after cardiac death (DCD).

From the technical point of view, with the EVLP technique both lungs are perfused and ventilated *ex vivo* at body temperature. Lungs are connected to the system through custom made silicon cuffs sutured to the main pulmonary artery (PA) and to the left atrium and an endotracheal tube is inserted into the trachea. Vascular cannulas are then connected to an ECMO circuit for perfusion and the endotracheal tube is connected to a mechanical ventilator [5].

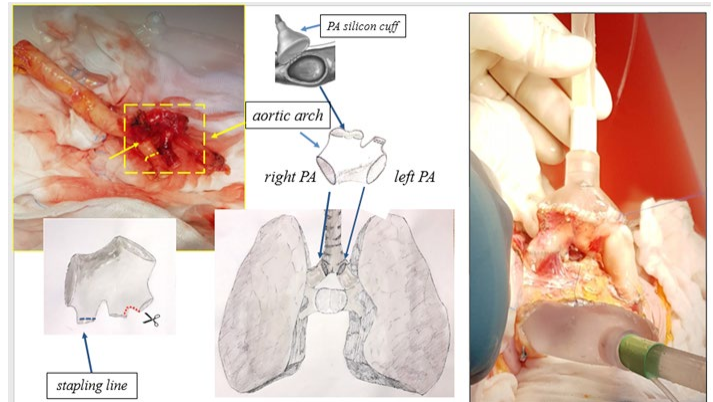
Nowadays - being the utilize of EVLP platform a robust part of clinical practice as demonstrated by several studies [5,12] a meticulous lung retrieval technique is essential: in particular, an adequate length of pulmonary vessels and trachea should be maintained in order to facilitate the connection of the lungs to the system.

In this paper we report a case of accidental division of the main pulmonary artery (PA) during the harvesting, that required an original technique to reconstruct the anatomy of the pulmonary artery main trunk and eventually offered the opportunity to successfully connect lungs to the EVLP system.

## Case

We report a case of a successful EVLP after retrieval in a 29-years-old donor deceased for a car accident with associated chest trauma. Despite bilateral infiltrates on CT-scan, lung function was satisfactory with a P/F ratio of 440 mmHg. During surgical evaluation P/F ratio dropped to 280 mmHg, with lungs maintaining optimal compliance except for the right lower lobe showing some degree of contusion probably due to the chest blunt trauma. As a result after the assessment we decided to proceed anyway with the retrieval, still planning a further evaluation via EVLP platform. Unfortunately, during the harvesting that was carried out in cooperation with a cardiac surgeons (heart harvesting was planed also), the main PA trunk was accidentally divided leaving right and left branches disconnected, thus posing a crucial issue for the EVLP cannulation. Once back to our hospital we evaluated the damage and in order to connect the graft to the PA cuff of the EVLP system, we planned main PA reconstruction using donors aortic arch with a portion of the cadaveric aorta (i.e. supra-aortic trunks)

As showed in figure 1, ascending aorta was sutured to the right pulmonary artery, descending aorta was sutured to the left pulmonary artery, left subclavian artery was stapled and the junction between brachio-cephalic trunk and left carotid artery was sectioned in order to obtain an adequate vessel to be anastomosed to the silicon cuff.



**Figure 1:** Ascending aorta was sutured to the right pulmonary artery, descending aorta was sutured to the left pulmonary artery, left subclavian artery was stapled and the junction between brachio-cephalic trunk and left carotid artery was sectioned in order to obtain an adequate vessel to be anastomosed to the silicon cuff.

Before starting the EVLP procedure a right lower lobectomy was required due to massive contusion evident in this area. EVLP was started according to Toronto protocol, and after 4 hours of EVLP lungs were considered suitable for transplantation. All the considered variables were satisfactory during the period of monitoring. P/F ratio reached 430 mmHg, left atrial and PA pressures remained both stable during procedure, bronchoscopy was negative and no signs of congestion on X-rays become apparent. Lung transplant was carried out on a 48-year-old recipient affected by primary pulmonary hypertension, performed through a clamshell incision with central VA ECMO support and switched to femoral VA ECMO at the end of the surgical procedure. This was progressively lowered until removal after 48hrs. Postoperative period was uneventful, still characterized by slow recovery; the patient was discharged on 51st postoperative day. Follow-up after 1year is in keeping with a satisfactory recovery.

## Discussion

Organ shortage remains a key limiting factor to the widespread application of lung transplantation. Considerable efforts have been made to increase organ donation. This includes: a) utilization of organs that were previously considered not suitable ("marginal donors"); b) potential donors have been managed by trained healthcare experts instead of unqualified professionals with particular attention to increase the number of acquired consents from families; c) clinical management in the Intensive Unit Care have been optimized adopting clinical strategies previously shown to be effective in critically ill patients; d) harvesting of lungs from donation after controlled (cDCD) or uncontrolled cardiac death (uDCD); e) the lobar living lung donor program represents an emerging clinical entity in some countries. Among all these strategies, the normothermic EVLP has been proved

able to improve the number of available lungs through two major routes: first, the “reconditioning” of injured lungs toward clinical acceptability and second a more accurate and prolonged evaluation of marginal lungs prior to their implant. Additionally EVLP has the potential of improving lung assessment and testing of organ quality; facilitating organ self-repair mechanisms; providing a stable platform for active drug or molecular treatments; and safely prolonging the preservation period of the organs [13-16].

EVLP requires intact vessels and airways in order to be properly performed. Precise levels of division of main PA trunk and left atrial cuff during harvesting are critical maneuvers which may incidentally result in PA injury or short vein stumps. Additional care should be taken when the EVLP process is planned. In our case arterial stumps were separated making it impossible to connect the cuff to the pulmonary arterial system. Aortic arch may be retrieved together with lungs as it is not needed by the cardiac team. Aortic arch was then retrieved and used to restore the normal anatomy of the main pulmonary artery bifurcation in order to suture the cuff to the vessel. No anastomotic leak was evident throughout the procedure, pulmonary artery pressure was monitored correctly and EVLP was performed as in normal anatomy using a standardized circuit.

## Conclusion

This article highlights successful EVLP reconditioning and lung transplantation, despite PA division during retrieval, reporting a technical detail to restore an adequate arterial length in order to overcome lack of tissue when connecting PA to the cannula.

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