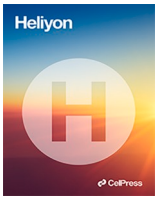
Heliyon 10 (2024) e29805

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon



Case report

Lung transplantation, case anecdotes reconstruction for inadequate left atrial cuff on the donor side by aortic arch: A feasible case report

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ARTICLE INFO

Keywords:
Inadequate left atrial cuff
Lung transplantation
Aortic arch
Restructure

ABSTRACT

Abnormalities in pulmonary vasculature or technical issues during lung procurement can lead to an insufficient left atrial (LA) cuff in donors. However, surgeons frequently need to reconfigure these less-than-ideal lungs for transplantation. This case report introduces a novel technique for such reconstruction. The patient was a 35-year-old male diagnosed with pneumoconiosis for over a year. Due to progressive worsening dyspnoea leading to respiratory failure on multiple occasions, he was deemed a candidate for lung transplantation. While obtaining the donor's lung, an inadvertent short cut of the LA cuff around the left inferior pulmonary vein orifice resulted in the residual vein retracting into the pulmonary hilum. To overcome this, we employed the aortic arch for reconstruction, enabling the successful completion of the lung transplantation. On post-transplantation day 2, extracorporeal membrane oxygenation was no longer required. Mechanical ventilation ceased after 13 days, with the subsequent removal of a tracheostomy. The patient spent 35 days in the intensive care unit and 58 days in the hospital. Post-transplantation complications included primary graft dysfunction, acute kidney failure, pneumothorax in the transplanted lung, the clots in the inferior vena cava, and pneumonia. Remarkably, over a year of follow-up (19 months after lung transplantation), the patient reported no adverse events and had successfully returned to work. In this case, the aortic arch is an alternative for reconstructing an insufficient LA cuff.

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https://doi.org/10.1016/j.heliyon.2024.e29805
Received 19 September 2023; Received in revised form 21 March 2024; Accepted 15 April 2024
Available online 16 April 2024

1. Introduction

Abnormalities within the pulmonary vasculature or technical complications encountered during lung procurement can result in an insufficient left atrial (LA) cuff in potential donors. This situation often necessitates the exclusion of the lungs from transplantation. However, given the persistent shortage of viable organs and the critical nature of the decision, surgeons are frequently compelled to utilize these suboptimal lungs for transplantation. While existing literature has discussed several techniques for repairing the inadequate LA cuff [1–4], there is a noticeable absence of evidence involving the reconstruction of an insufficient LA cuff using the aortic arch. Hence, this case report aimed to bridge this gap in the literature.

2. Case report

We have obtained informed consent from the patient for accepting organ transplantation, as well as for reporting clinical data, imaging, and other pertinent information related to this pulmonary transplantation. Furthermore, we have obtained approvals from the Ethics Committee for this pulmonary transplantation (2019KJTYLL009) and from the Institutional Review Board for the review of the patient's data in the digital medical recording system.

The recipient, in this case, was a 35-year-old male who had been diagnosed with pneumoconiosis for over a year.He was a former smoker with a 54 pack-year history, having quit smoking about a year before his admission. His occupation was stone carving. No comorbidities were identified. Prior to undergoing an intent-to-treatment unilateral lung transplantation, the recipient had faced a series of hospitalizations.

The patient's specific history unfolded as follows: approximately a year before transplantation, he was diagnosed with pneumoconiosis following spontaneous pneumothorax, which presented with dyspnoea, fatigue, and intermittent cough. These symptoms subsided after receiving medication treatment. Two months before transplantation, he experienced pneumonia due to pneumoconiosis, leading to progressively severe dyspnoea. So, he underwent medication treatment again. However, the disease seemed not significantly cured. His current admission was necessitated by these escalating issues, culminating in respiratory failure. The patient underwent a comprehensive set of blood examinations without abnormalities. The pre-transplant pulmonary function test indicated a vital capacity (VC) of 1.84 L, maximal voluntary ventilation (MVV) of 40.74 L/min, and a forced expiratory volume in 1 second (FEV_1) of 0.99 L. Additionally, the percentage of predicted FEV_1 (FEV_1%pre) was 25 %, and the FEV_1 to forced vital capacity ratio (FEV_1/FVC) was 83 %. The pre-transplant computed tomography (CT) scan taken is shown in Fig. 1A. Accordingly, we reaffirmed the diagnosis and recommended a lung transplantation.

The donor was a 58-year-old male with a history of smoking, who experienced brain death. A CT scan indicated normal lung structure and a bronchoscopy revealed unobstructed airways. However, during the procurement, the LA cuff encircling the orifice of the left inferior pulmonary vein was inadvertently cut too short. As a consequence of this, the remaining portion of the vein retracted into the pulmonary hilum (Fig. 2A). Since the aortic arch had not been used during the heart procurement, we opted to utilize it for reconstruction (Figs. 2B and 3).

Before reconstruction, the aortic arch, including the left subclavian artery, left common carotid artery, and brachiocephalic trunk, was prepared to match the pulmonary vein orifice and LA. Using 5-0 polypropylene sutures, we anastomosed the left subclavian artery

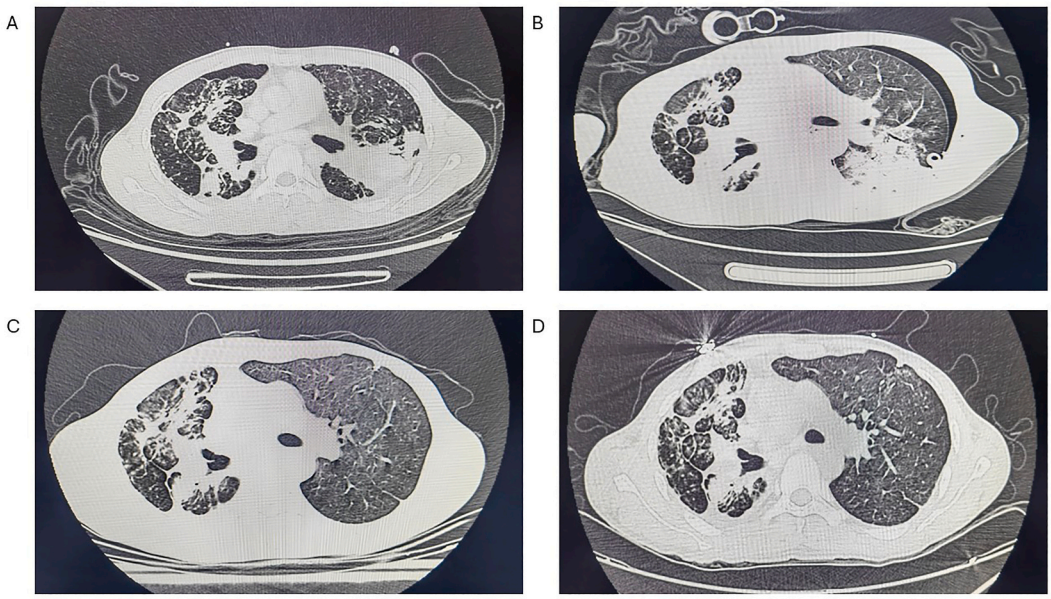

Fig. 1. CT scans timelines: pre-transplantation (A), pneumonia (B), discharge (C), and post-transplant month 19 (D).

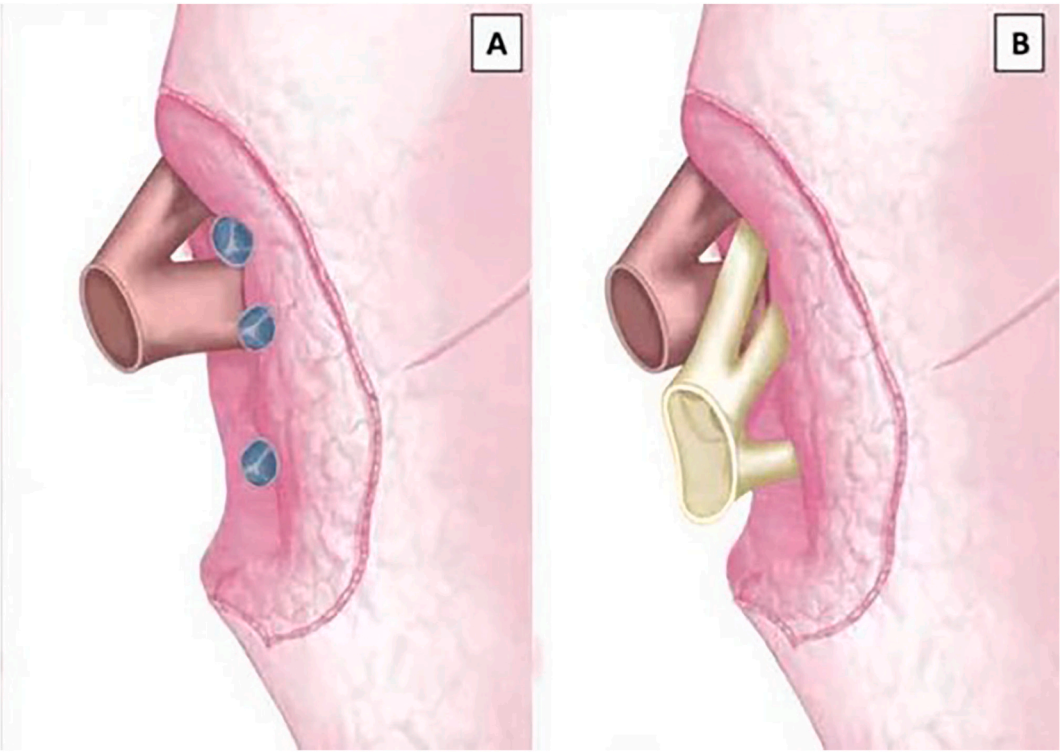

Fig. 2. Insufficient donor left atrial cuff (A) and reconstruction by aortic arch (B).

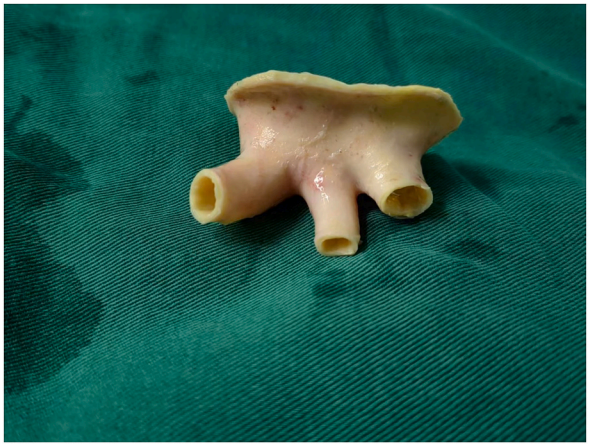

Fig. 3. The aortic arch from the donor.

with the appropriate segmental vein, the left common carotid artery with the lingual segmental vein, and the brachiocephalic artery with the inferior pulmonary vein. Then we constantly sutured the aortic arch and atrial cuff with 4-0 polydioxanone sutures. And the trachea was sutured continuously using 4-0 polypropylene and reinforced with mediastinal pleura. The completed reconstruction is shown in Fig. 4.

During the intraoperative phase, we encountered two adverse events: substantial blood loss and pulmonary edema, the latter due to stenosis in the pulmonary vein anastomosis. To manage these complications, we implemented blood transfusion, increased fluid administration, and performed a secondary anastomosis connecting the brachiocephalic artery and the inferior pulmonary vein. After lung transplantation, transesophageal echocardiogram and CT pulmonary angiography found no vascular anastomotic complications.

Immediately following the lung transplantation, the patient developed primary graft dysfunction (PGD) and acute kidney injury (AKI). These two complications were attributed to factors including intraoperative challenges, post-transplant inflammatory responses, and adverse effects related to the prescribed medications. In response, we initiated therapeutic drug monitoring and employed

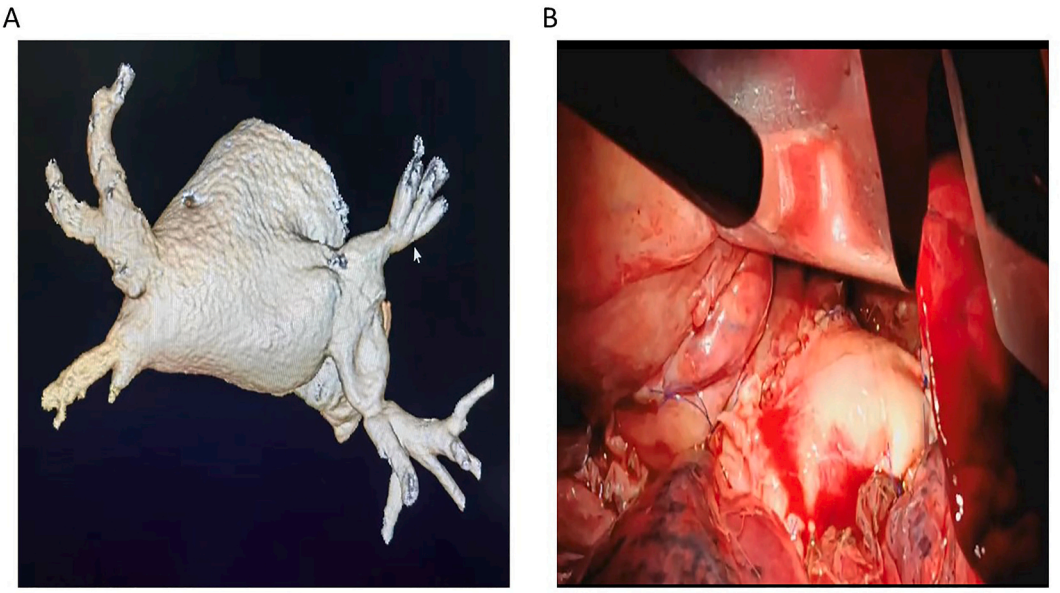

Fig. 4. Three-dimension image after reconstruction (A) and in-vivo status (B).

continuous renal replacement therapy (CRRT). Additionally, we carefully adjusted fluid administration to maintain hemodynamic stability.

The strategy of protective lung ventilation, as detailed in our previously published literature [5], is routinely implemented in clinical practice.

On post-transplant day 2 (PTD 2), extracorporeal membrane oxygenation (ECMO) was no longer required. Following this, vascular ultrasound raised suspicions of blood clots in the inferior vena cava, confirmed by a transesophageal echocardiogram (a maximum blood flow speed of 1.77 m/s). It was possibly related to ECMO. We initiated treatment with low molecular weight heparin, administering 5000 IU injections every 12 hours, later transitioning to oral rivaroxaban at 20 mg once daily. During this period, the patient underwent weekly vascular ultrasounds until the clots resolved, after which the frequency of this examination was reduced to monthly.

Pneumothorax in the donor lung, noted on PTD 4, necessitated a re-operation.

For empiric antibacterial therapy and prophylaxis against opportunistic infections after lung transplantation, we combined Meropenem, Caspofungin, and Ganciclovir. Mechanical ventilation continued until PTD 15, at which point pneumonia was diagnosed. The diagnosis was based on a post-bronchoscopy sputum examination, which detected Stenotrophomonas maltophilia in both the native and transplanted lungs, supplemented by corresponding blood tests and a CT scan (Fig. 1B). We thus substituted Meropenem with Cefoperazone for the patient. By PTD 21, sputum examinations showed negative results, and we removed the tracheostomy from the patient on PTD 22.

Post-transplant physiotherapy commenced from PTD 1. Initially, the patient's movements on the bed were entirely passive. Gradually, he progressed to partially passive mobilization, eventually achieving independent mobilization and ambulation. These excises were accompanied by pulmonary function training.

Our institutional protocol for post-transplant immunosuppression consists of immune induction and maintenance phases. For induction, Methylprednisolone at 10 mg/kg and Basiliximab at 20 mg were administered intraoperatively, with Basiliximab continuing until PTD 4. During the maintenance phase, we started with Tacrolimus at 0.04 mg/kg, aiming to maintain blood concentrations between 6 and 12 mg, adjusted as needed for inflammation and renal function. Methylprednisolone, initially at 0.5 mg/kg, was switched to Prednisone at the same dosage on the third day, gradually reducing by 5 mg per week to a maintenance dose of 0.25 mg/kg. Mycophenolate mofetil was introduced at 0.5 g every 12 hours, providing no infection risk.

Throughout the course of treatment, the patient spent 35 days in the intensive care unit and an additional 58 days in the common ward. The CT scan performed prior to discharge is presented in Fig. 1C.

The follow-up program after discharge included a comprehensive set of examinations. For the first six months, the patient underwent blood tests, including assessments of blood sugar, hepatic and renal functions, Tacrolimus blood concentration, procalcitonin levels, and T cell counts, bi-weekly. Additionally, cytomegalovirus DNA and blood lipid levels were monitored monthly, while CT scans, pulmonary function tests, and bronchoscopies were conducted every three months. After the initial six months and up to one year post-discharge, the frequency of most tests shifted to monthly, except for CT scans, pulmonary function tests, and bronchoscopies, which continued every three months. Beyond the first year post-discharge, CT scans, lung function tests, and bronchoscopies were performed every six months, with all other examinations continuing monthly.

Over a year of follow-up (19 months after transplant), the patient reported no adverse events and successfully resumed work. The latest CT scan during the follow-up interval is reported in Fig. 1D. Additionally, the most recent pulmonary function test indicated a VC

of 2.20 L, MVV of 69.74 L/min, FEV1 of 1.95 L, with FEV_1 at 49 % of the predicted value and an FEV_1/FVC of 83 %.

3. Discussion

This is the first report regarding the LA cuff restructuring using the donor's aortic arch. The aortic arch is typically not used in heart transplantation, as it is not procured from the donor. Hence, the aortic arch is a natural material for restructuration when we meet an inadequate left atrial cuff in lung transplantation.

Oto T and colleagues have provided an overview of various techniques to address an inadequate LA cuff in donor cases [6]. Their work has demonstrated the efficacy of reconstructing an insufficient donor LA cuff using artificial materials or human tissues.

In our opinions, compared to the pericardium, the aortic arch is thicker with better ductility, potentially indicating that the requirement for suture technique might not exceed that of using pericardium. Notably, the aortic arch offers a superior fit compared to the pulmonary artery, superior vena cava, and posterior left atrium, explicitly matching the anatomical shape of the pulmonary vein and LA cuff. Furthermore, the histological characteristics of the aortic arch are the same as those of the pulmonary vein and LA cuff.

As for the other approach involving the creation of an oval cross-sectional cuff to address the challenge of an inadequate LA cuff [3, 6], it shares similar effectiveness to ours. However, it may not be suitable for addressing the specific issue that arises on the donor side when the length of the pulmonary veins is insufficient.

Additionally, the feasibility of employing a biological patch for the reconstruction of an inadequate LA cuff has been reported [4]. Nevertheless, the expense associated with the utilization of artificial materials may exceed the cost of employing human tissue.

In reflecting upon this case, we have identified three key lessons in the care. Firstly, the transesophageal echocardiogram, employed both during and after the transplantation by us, proved effective in evaluating venous complications, corroborated by findings from a previous case report [7]. Secondly, a previous study highlighted that PGD within the first 72 hours post-transplantation was a critical indicator [8]. This phenomenon was associated with various injury responses and poorer survival rates. In this case, the PGD occurred within a remarkably short period following the transplantation. Post-transplant AKI and pneumonia might be linked to PGD. According to the other prior study, post-transplant AKI, particularly cases requiring CRRT, significantly increased the risk of pneumonia and prolonged hospital stays, ultimately portending worse survival outcomes after lung transplantation [9]. Furthermore, as we all know, pulmonary infections are associated with notably adverse outcomes [10]. Although, in this case report, the patient remains alive and asymptomatic to date, the potential exists for these post-transplant complications to impact future follow-up outcomes. Therefore, we should emphasize the need for further improved preventative and treatment strategies for PGD. Thirdly, while the aortic arch offers several advantages as a restructuring option for an insufficient LA cuff compared to other methods, minimizing human error in these procedures remains crucial.

4. Conclusion

The aortic arch serves as an alternative for reconstruction of an insufficient LA cuff. Nevertheless, it is crucial that further clinical practice and relevant trials be conducted to validate and solidify the efficacy of this technique.

Funding statement

No funding or grant was received for the research.

Data availability statement

The full setup raw data is available upon request.

Additional information

No additional information is available for this paper.

CRediT authorship contribution statement

Weidong Wu: Project administration, Resources, Software, Visualization, Writing – original draft, Writing – review & editing, Conceptualization, Data curation, Formal analysis, Investigation, Methodology. **Lin Huang:** Conceptualization, Formal analysis, Investigation, Methodology, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Bing Ye:** Writing – original draft, Writing – review & editing, Conceptualization, Data curation, Investigation, Resources, Validation. **Bin Zheng:** Data curation, Project administration, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing. **Chun Chen:** Conceptualization, Project administration, Resources, Software, Supervision, Validation, Writing – original draft, Writing – review & editing. **Jingyu Chen:** Conceptualization, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The authors would like to thank all members in the Lung Transplantation Program at Fujian Medical University Affiliated Union Hospital. Also, we would like to thank patients and their families for permission to share this case.

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