



## Editorial

# Robotic Lung Transplantation: A Paradigm Shift in Surgical Strategy



Since its beginnings, the field of lung transplantation has witnessed remarkable advancements and has become a viable therapeutic option for patients with advanced lung diseases. Drawing upon the pivotal work of pioneers such as Dr. Cooper, Dr. James, D. Hardy, and the Toronto Lung Transplant Group,<sup>1</sup> the journey of lung transplantation has been waymarked by notable breakthroughs.

Lung transplantation often requires the use of highly invasive incisions, including the clamshell incision (CS), sternotomy, and anterior/posterolateral thoracotomy. These approaches are often associated with unfavourable outcomes such as increased inflammation, heightened postoperative pain, and issues such as phrenic nerve paresis causing breathing problems. Wound healing can be compromised, leading to wound dehiscence and vulnerability to infections, even osteomyelitis.<sup>2</sup> These outcomes can significantly affect the recovery process and impact negatively on patients' overall quality of life.

Lung transplantation has transitioned from extensive bilateral thoracotomy with sternal division to less invasive approaches, such as small bilateral thoracotomies without sternal division. Researchers have also explored endoscopic methods, which offer the potential for less invasive techniques.<sup>3</sup> However, these approaches have not yet been widely adopted, and only a few minimally invasive surgical options for lung transplantation have gained traction.

In the field of thoracic surgery, the emergence of minimally invasive techniques such as video-assisted thoracoscopic surgery (VATS) and robot-assisted thoracic surgery (RATS) has brought about a notable shift in surgical practices, and these techniques have become the standard for elective surgical procedures. Our substantial experience in robotic surgery, with more than 350 robotic procedures conducted since 2018, alongside our extensive proficiency in lung transplantation with over 1500 procedures performed since the programme's inception, highlights this transformation, particularly in complex surgeries. Positive outcomes have strengthened our confidence and paved the way for an ambitious move: the implementation of a programme for robotic lung transplantation.

Our programme began with several months of detailed research, careful planning, and the creation of a surgical plan. The steps from idea to action were carefully thought out and followed a well-designed path. One of our major challenges was the extraction of the native lung and the introduction of the graft without resorting to traditional thoracotomies. It was at this juncture that we

collectively determined to harness the subxiphoid approach, well-documented in thoracic surgeries, and seamlessly integrate it into our routine clinical practice.

Initially, we conducted practice simulations in a controlled environment using simulation materials. Once we had refined our technique, we proceeded to an experimental phase. Collaborating with a specialized institution focused on training for minimally invasive surgery (Minimally Invasive Surgery Centre Jesús Usón), we performed two successful left single lung transplant procedures in sheep. This accomplishment validated the precision of our pre-planning and methodological approach.

After conducting the essential animal experiments, we transitioned into a critical phase of meticulous planning and preparation. This involved the development of comprehensive surgical protocols that outlined the procedure in detail. These protocols served as a roadmap for our surgical team, ensuring a systematic and precise approach to each aspect of the robotic lung transplantation.

Concurrently, we embarked on an extensive educational training within our medical staff. Our anaesthesia and nursing teams were integral to the success of the procedure, and we conducted rigorous training sessions and interactive workshops to acquaint them with the technical nuances. This knowledge-sharing phase played a crucial role in ensuring a smooth and effective process, ultimately leading to favourable outcomes.

The surgery began with patient positioning under general anaesthesia and a double-lumen endotracheal tube. Using the robotic platform, four ports were placed, along with a subxiphoid approach. This enabled the meticulous dissection of the pulmonary hilum, transection of the pulmonary artery and vein with robotic staplers, and division of the main bronchus, ultimately leading to a controlled pneumonectomy. The recipient's lung was removed through an 8 cm subxiphoid incision, and the graft was inserted through the same incision.

Following the pneumonectomy, established techniques were used for bronchial, arterial, and pulmonary vein anastomoses. Bronchial anastomosis employed an end-to-end suture technique. The pulmonary artery was clamped using an endoscopic vascular clamp, followed by a half-continuous anastomosis. Subsequently, clamping of the left atrium and anastomosis of the recipient's left atrium to the donor's atrial cuff was performed using the same suture technique. Haemostasis was achieved after reperfusion and ventilation. Two chest tubes were placed for drainage, and importantly, no extra haemodynamic support, such as ECMO or CPB, was needed during the surgery.

The first case was a 65-year-old male recipient (height 180 cm, weight 86 kg) with severe restrictive ventilatory disorder due to end-stage usual interstitial pneumonia and significantly compromised functioning and daily life. After 21 days on the transplant waiting list, a compatible donor lung became available. A 72-year-old non-smoking female donor, with a body weight of 44 kg, height of 165 cm, and PaFi of 492 mmHg, was selected. The donor lung underwent thorough assessment and was prepared for the transplant to the recipient. Following surgery, the patient experienced minimal postoperative pain, which significantly facilitated a swift recovery during the hospitalization phase.

In the second case, a 71-year-old male (height 164 cm, weight 65 kg) with pulmonary fibrosis and reliance on home oxygen therapy received a left single lung transplant. He had severely restrictive respiratory patterns and decreased diffusion capacity. A 22-year-old non-smoking male donor was deemed suitable, and the transplantation procedure was performed. Mimicking the approach in first case, positive outcomes were achieved without extracorporeal support. Following surgery, as in the first patient, the postoperative phase for this case was characterized by minimal pain. The wound healing process was notably successful, necessitating only regular analgesia, with no opioids. This pain management approach enabled effective early-phase physiotherapy, contributing to the patient's postoperative progress.

Lung transplantation remains the primary viable option for patients with advanced pulmonary failure. Nevertheless, traditional lung transplant methods generate significant challenges and complications, in both the immediate and long term. The integration of robotic technology into thoracic surgery has shown promise, offering improved precision and effective management of complex procedures. Patients who undergo robotic lung transplantation could experience less postoperative pain, along with well-healing incisions. This not only contributes to their overall comfort but also facilitates greater adherence to postoperative physiotherapy, potentially reducing complications directly associated with surgery. Successful instances of robot-assisted lung

transplantation underscore the potential for promoting less invasive techniques in this field. However, further research is essential to comprehensively evaluate the advantages of this approach.

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### Conflict of Interest

The authors declare to have no conflict of interest directly or indirectly related to the manuscript contents.

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Fernando Ascanio\*, Iñigo Royo-Crespo, Alberto Jauregui  
*Department of Thoracic Surgery and Lung Transplantation, Hospital Universitario Vall d'Hebron, Barcelona, Spain*

\* Corresponding author.

E-mail address: [fernando.ascanio@vallhebron.cat](mailto:fernando.ascanio@vallhebron.cat) (F. Ascanio).