Real-Time Computed Tomography Highlights Pulmonary Parenchymal Evolution During Ex Vivo Lung Reconditioning

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Ex vivo lung perfusion (EVLP) has been developed as a method to reassess and recondition marginal lungs. However, evaluation during procedures is limited to a combination of physiologic variables such as gas exchange, pulmonary mechanics, and pulmonary vascular resistance. The aim of this study was to analyze the feasibility of real-time computed tomographic (CT) imaging to improve the evaluation of the lung during EVLP procedures.


Over the past decade, the number of lung transplantations has increased worldwide but not enough for the number of candidates. Ex vivo lung perfusion (EVLP) has been developed as a method to reassess and recondition damaged lungs, [1, 2], thereby increasing the donor pool. Lungs undergoing EVLP do not show significantly different postoperative results compared with standard lungs [3]. During EVLP, hemodynamic and aerodynamic measurements are checked as well as gas-exchange capacity.

A standard roentgenogram could easily be obtained during EVLP, which could help to evaluate the evolution of lung infiltration over this period. However, such images lack precision and a computed tomographic (CT) scan could be better for lung parenchyma evaluation.

We aimed to evaluate the feasibility and utility of a real-time CT scan using the O-Arm (Medtronic Inc, Minneapolis, MN) to evaluate lung parenchymal evolution during EVLP.

We used the Toronto protocol, as previously described, for reconditioning lungs [2].

To assess the graft we used functional and morphologic measurements.

To evaluate the lung parenchyma, we used the O-Arm, a mobile cone-beam imaging system that combines a traditional fluoroscope in 2 dimensions and a CT scanner offering high-resolution images (Fig 1) during EVLP at 1 and 4 hours.

The decision to transplant was made based on recovered physiologic function with an arterial partial pressure of oxygen/fraction of inspired oxygen (P/F) ratio greater than 400 mm Hg, as well as improvement or stability of the other functional measurements. We evaluated 3 consecutive extended-criteria, brain-dead donor lungs that were reconditioned in EVLP using the O-Arm.

The first donor died after a stroke. Ventilation duration was 3 days. Bronchoscopy showed purulent secretion in the right lower lobe. The P/F ratio was 348, and the donor score was 11. First cold ischemia time was 228 minutes and the EVLP time was 287 minutes.

The second donor died after a high kinetic trauma with head and chest lesions. Ventilation duration was 1 day. Bronchoscopy showed a bloody secretion in the left lung. The P/F ratio was 229, and the donor score was 11. First cold ischemia time was 185 minutes, and the EVLP time was 281 minutes.

The third donor died after a stroke. Ventilation duration was 7 days, and a gastric aspiration was suspected. Bronchoscopy showed an abundant purulent secretion in the right lower lobe. The P/F ratio was 220, and the donor score was 14. First cold ischemia time was 168 minutes, and the EVLP time was 240 minutes.

For donors 1 and 2, the O-Arm evaluation highlighted an attenuation of ground-glass opacification and better lung inflation (Fig 2). Because they were associated with recovered physiologic function, the grafts from donors 1 and 2 were transplanted.

For donor 3, the O-Arm showed an increase of parenchymal opacification (Fig 2). Because clinical and functional measurements evidenced a deterioration of clinical and physiologic factors, the lungs from donor 3 were not transplanted.

The 2 patients who underwent transplantation were extubated in the operating room. No pulmonary graft dysfunction was observed within 72 hours. The length of stay was 1 day in the intensive care unit and 20 days in the hospital for recipient 1 and 6 days in the intensive care unit and 34 days in the hospital for recipient 2.

Comment

The use of EVLP allows evaluation and reconditioning of marginal or unacceptable donor lungs before transplantation [1, 2]. The Toronto EVLP protocol uses a combination of reduced inflammatory cytokines through an acellular perfusate together with a hyperoncotic composition of Steen solution (XVIVO Perfusion, Göteborg, Sweden) to fight edema formation [1]. However, during the procedure, the Toronto group advises that the arterial partial pressure of oxygen be combined with other physiologic measurements, such as airway pressure and compliance, to define a transplantable or nontransplantable lung [3].

Thus Trebbia and associates [4] proposed to improve the assessment during EVLP by measuring the amount of...
Pulmonary edema is an increased loss of fluid initially into the pulmonary interstitium and then into the alveoli. Therefore, the diagnosis can be made by chest roentgenography, but this does not provide as much information as a CT scan.

Even though lung graft parenchymal evaluation by CT has already been described before and after EVLP [5, 6], we report the first use of the O-Arm [7] for real-time CT imaging during EVLP. Indeed, in our experience with marginal brain-dead donors, it is often difficult to determine the difference between established (pneumonia, contusion) and reversible (atelectasis, neurogenic edema) lung injuries, even at the donor site. With this technology, we obtained high-definition images of the lung parenchyma during EVLP. Interpretation of the images highlights parenchymal evolution. Improvement could be explained in the first case by an association of bronchoscopy and targeted lung recruitment that led to a disappearance of atelectasis. In the second case, the decrease of edema might be explained by the effect of the Steen solution as a hyperoncotic perfusate. Those parenchymal constatations were correlated with the other functional measurement.
improvements. Conversely, for the third graft, CT scanning showed deterioration of alveolar images correlated with a decrease in the other functional measurements. Even if the results of the CT scan were not discriminating in the decision to transplant, the parenchymal picture evolution allowed us to consolidate our decision.

In conclusion, this preliminary report of real-time CT scanning during EVLP seems to be a powerful tool for lung parenchymal evaluation. Further investigation is required to confirm the place of this technology as an additional measurement for improving lung graft selection.

References


