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Allocation of Donor Lungs in Korea

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The expansion of indications for lung transplantation, the growth of the waiting list, and donor shortages are increasing the waiting list mortality rate in Korea. The current lung allocation system in Korea is based mainly on urgency, but outcomes should also be considered to avoid futile transplantation. This review describes the current status of, and issues with, the lung allocation system in Korea including donors, the waiting list, and transplant outcomes in the context of an aging society, in which the frequency of end-stage pulmonary disease is increasing.

Keywords: Lung transplantation, Waiting lists, Resource allocation, Donor, Survival

Introduction

Lung transplantation is the only palliative treatment option for some patients with end-stage lung disease [1]. Since the first successful single lung transplantation was performed in 1996 in Korea, the number of transplants has been increasing annually, and 157 were performed in 2019 [2,3]. However, the number of patients on the waiting list for transplants also continues to increase. In 2019, 277 patients were on the waiting list for lung transplants, and there is a large gap between the demand for and availability of donor lungs. As a result, 82 candidates died while waiting for a transplant in 2019, representing a 7.9% increase from the previous year [2]. This gap is expected to further widen as the elderly population and number of patients with end-stage lung disease in need of lung transplantation increase [4]. Organ allocation systems are crucial for the fair and efficient distribution of donor lungs. This review describes the current lung allocation system in Korea, focusing on the major issues associated with donors, the waiting list, and transplant results.

Current Korean lung allocation system

Korea established the Korean Network for Organ Sharing in 2000. Since then, efforts have been made to distribute and manage organs fairly and efficiently according to the Internal Organs Transplant Act [5]. The current donor lung allocation system is based mainly on urgency, with additional points allocated according to region, blood type, wait time, previous donation history, and age [6]. Transplant candidates are classified as 0–4 according to urgency; a lower status indicates a higher priority. Status 0 corresponds to a hospitalized patient on a mechanical ventilator and/or extracorporeal membrane oxygenation (ECMO) due to respiratory failure. Status 1 is defined as the presence of 1 or more of the following: partial pressure of oxygen (PaO_2) <55 mm Hg, as measured without oxygen administration; mean pulmonary arterial pressure >65 mm Hg or mean right atrial pressure >15 mm Hg; cardiac index <2 L/min/m^2; partial pressure of carbon dioxide ($PaCO_2$) ≥80 mm Hg; or hospitalization for >2 weeks with a high-flow nasal cannula (30 L, fraction of inspired oxygen ≥0.6). Status 2 is defined as the presence of one or more of the following: forced expiratory volume in 1 second (FEV1) <25%; PaO_2 <60 mm Hg, as measured without supplemental oxygen; average right atrial blood pressure of 10–15 mm Hg; average pulmonary arterial pressure of 55–65 mm Hg; cardiac index <2–2.5 L/min/m^2; 70 mm Hg≤ $PaCO_2$ <80 mm Hg; or diffusing capacity of the lungs <30% on a pulmonary function test. Status 3 is defined as the presence of 1 or more of the following: requirement for a single lung transplant; emphysema, pulmonary hypertension, or diffuse interstitial lung disease; FEV1 <30%; or hospitaliza-

tion more than three times for respiratory failure. Status 4 is the classification for all other patients.

Donor shortages and increased use of marginal donors

The number of brain-dead donors in Korea steadily increased to 450 in 2019. However, only 13% of brain-dead donor lungs are used for lung transplantation [7,8]. Donor lungs can be injured by a proinflammatory cytokine or catecholamine surge after brain death. In addition, the lungs are vulnerable to parenchymal damage, such as pulmonary infection, aspiration, and pulmonary edema, after brain death in the intensive care unit [9]. Furthermore, many potential lung donors do not consent to lung donation, and the rate of lung donation remains lower in Korea than in other countries [10]. This is attributed to cultural factors and laws regarding organ donation [11]. Due to the shortage of donor lungs, attempts have been made to increase the donor pool worldwide, such as by extending the donor criteria and considering ex vivo lung perfusion (EVLP) and the use of donors after circulatory death (DCD). Currently, EVLP and DCD are not legal in Korea, and the use of marginal donors has increased by more than 50% [6,8]. EVLP is actively used in the United States and Canada to increase organ availability, and in some cases, organ quality is improved by using the prone position [12-14]. EVLP should be introduced to expand the pool of suitable donor lungs and reduce the average wait time of transplant candidates [15]. Similarly, permitting donations after cardiac death would increase the donor pool. Organ management centers should actively select and manage potential lung donors to maximize utilization of this valuable resource; an optimal donor management protocol and relaxation of the donor criteria are required.

Waiting list outcomes

A total of 1,671 patients were registered for lung transplantation from 2009 to 2020. Approximately half of these patients (46.1%) received transplants within 1 year of registration, while 31.8% died within 1 year without lung transplantation. The current system in Korea selects recipients based on urgency to decrease waiting list mortality. However, the waiting list mortality rate is still higher than in other countries (transplant rates/waiting list mortality: United States, 71.7%/14.4%; United Kingdom, 45%/17%; Japan, 37%/36.1%) [8-10]. Waiting list outcomes are affected by the donor pool, the efficiency of the allocation system, and the timing of registration. Status 0 patients are prioritized for transplants in urgency-based systems, and the proportion of highly urgent recipients has steadily increased. In Korea, most patients on the waiting list have interstitial pulmonary fibrosis (IPF) or another interstitial lung disease, and are at risk of rapid deterioration [6]. Therefore, registration and transplantation rates for highly urgent cases, such as those requiring ECMO, are high compared to other countries (e.g., <10% in the United States) [16]. In 2019, 68.6% of Korean transplant patients were status 0, and 38.5% underwent ECMO as a bridge to transplantation. Lung transplantation in Korea is still in the "learning phase," and a lack of awareness among patients and/or their physicians about lung transplantation can delay registration. Therefore, there is a need to educate the general population and doctors regarding lung transplantation. Continuous improvements to the allocation system will also reduce waiting list mortality and ensure equal transplant opportunities.

Transplant outcomes

The 1-year survival rate after transplantation has been steadily improving, and it reached 76.3% in 2019. The 1-year survival rate of transplantation for status 0 patients is 74.8%, and that for status 1 patients is 79.6%. The survival likelihood after transplantation is significantly affected by recipient age and urgency status at registration. The rate of lung transplantation in patients aged >65 years rose to 19.9% in 2019, of whom 61.3% were status 0 patients; most transplants in older patients were performed because of IPF (72%). The number of older patients with IPF undergoing transplants has also increased in the United States, but there have been no reports focusing on transplantation in patients with a highly urgent status, like those who receive transplants in Korea [17]. In particular, one-third of elderly patients were first registered for transplantation as status 0 patients. The main issue is that the referral of potential candidates to the transplant center is delayed.

In Korea, the 1-year survival rate for transplant patients aged ≥65 years was 67.7% in 2019, while the transplant survival rates of status 0 and 1 patients were 68.4% and 70%, respectively. Although the short-term survival rate is comparable to other age groups, older patients have relatively low intermediate- and long-term survival rates, and are at a high risk of post-transplant complications and morbidities [17]. Furthermore, pre-transplant evaluation is not possible for patients who are already in a highly urgent condition when registered, and the condition of these pa-

tients means that transplantation is likely to be futile [18]. Therefore, clinicians should recommend transplantation earlier to patients and their legal guardians.

Conclusion

Lung transplantation continues to develop in Korea. However, despite rapid technical advances, cultural factors have caused donor shortages, delayed registration of candidates, resulted in futile transplantations, and affected outcomes. Professionals involved in transplantation should work together to achieve a cultural shift; in the meantime, DCD and EVLP would help increase the donor pool.

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Author contributions

All work was done by Hye Ju Yeo.

Conflict of interest

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