Review Article

Donor management and extremely high donor lung utilization rate in Japan

Yasushi Hoshikawa[1]^, Yasushi Matsuda[1], Juntaro Ashikari[2]

[1]Department of Thoracic Surgery, Fujita Health University, Toyoake, Japan; [2]OrganTransplant Network, Tokyo, Japan

Contributions: (I) Conception and design: Y Hoshikawa; (II) Administrative support: None; (III) Provision of study materials or patients: None; (IV) Collection and assembly of data: Y Hoshikawa; (V) Data analysis and interpretation: Y Hoshikawa; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Yasushi Hoshikawa, MD, PhD. Department of Thoracic Surgery, Fujita Health University, 1-98 Dengakugakubo, Kutsukake-cho, Toyoake, Aichi, 470-1192 Japan. Email: yasushih@fujita-hu.ac.jp.

Abstract: Owing to the extremely short supply of donor lungs in Japan, a unique medical consultant (MC) system was initiated in 2002 to increase the organ availability through intensive management of donors. First, heart transplant surgeons were sent to procurement hospitals as MCs to assess donor organ function and provide intensive care to donors. MCs requested that donor attending doctors perform frequent phlegm aspiration with a bronchoscope, leading to a higher lung availability and better outcomes after lung transplantation. Since 2011, 25 lung transplant surgeons have been registered as lung MCs to assess and manage donor lungs and communicate donor lung conditions to the lung transplantation teams. In 2014, the efficacy of this MC system on lung transplantation opportunities and outcomes was retrospectively reviewed. One hundred and eighty-seven brain-dead lung donor candidates were chronologically divided into three phases: I (May 1998 to November 2006, n=44) and II (December 2006 to January 2011, n=64), before and after MCs requested that local attending doctors perform aggressive bronchial suctioning using a bronchoscope, respectively; and III (February 2011 to January 2013, n=79), after the emergence of lung MCs. The lung utilization rates in phases I, II, and III were 61.4%, 71.9%, and 74.7% (per donor); 51.1%, 64.8%, and 67.7% (per lung, P=0.03). Graft death rates due to primary graft dysfunction in phases I, II, and III were 13.3%, 3.6%, and 3.7%, respectively (per lung, P=0.04). Recently, we analyzed the utilization rate of 63 brain-dead lung donor candidates for a period of one year, from June 2020 to May 2021, which was 83% (per donor). The lung MC system is effective in maintaining an extremely high lung utilization rate and favorable outcomes after lung transplantation in Japan.

Keywords: Donor lungs; medical consultant (MC); assessment; management; lung utilization rate

Submitted Feb 24, 2023. Accepted for publication Jan 19, 2024. Published online Feb 23 2024.
doi: 10.21037/jtd-23-290
View this article at: https://dx.doi.org/10.21037/jtd-23-290

Introduction

Cadaveric lung transplantation was initiated in Japan in 2000. From 2000 to 2009, only a few donations and lung transplantations were performed annually (*Figure 1*) (1). The revision of the transplantation law in 2010, which contained an alteration from a system requiring a donor's living written consent for cadaveric organ donation to that allowing donation with the family consent, and the removal of the donor age restriction of 15 years or older (2), resulted in a substantial increase in cadaveric donors and lung

^ ORCID: 0000-0003-3235-8253.

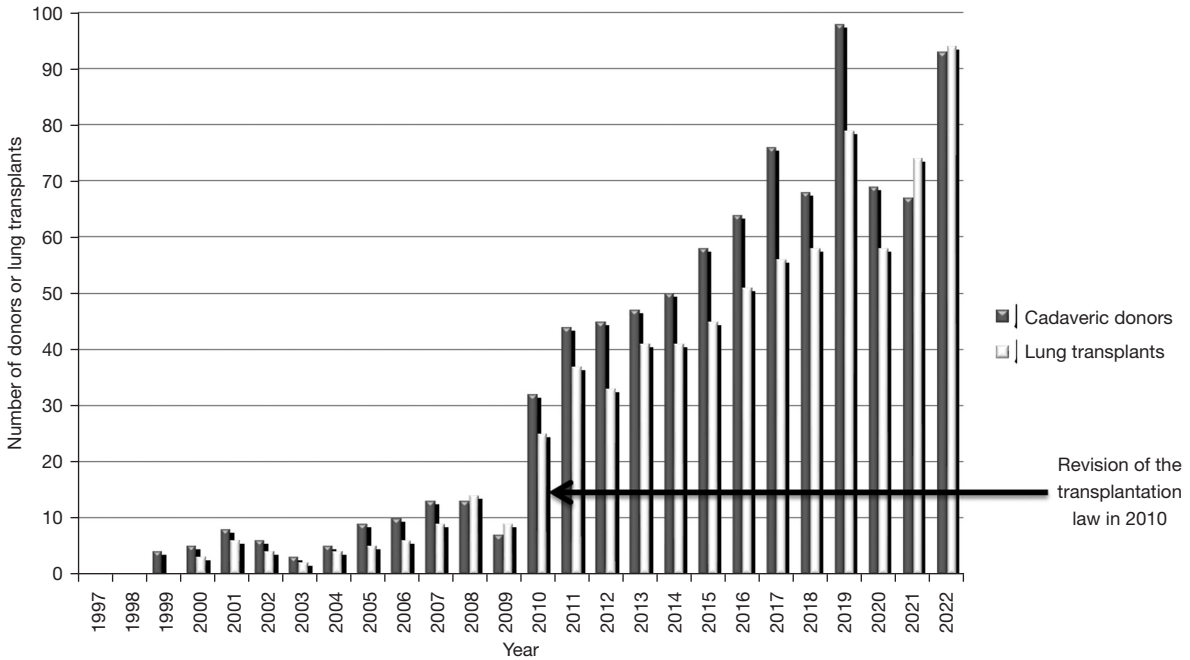

Figure 1 Number of brain-dead donors and lung transplantations reported by year in Japan. The gray and white columns represent the number of cadaveric donors and lung transplantations from cadaveric donors, respectively.

transplantations (*Figure 1*) (1). Meanwhile, an increase in the number of wait-listed patients for lung transplantation has been far exceeding that of cadaveric donors (*Figure 2*) (3). At the end of October 2022, cumulative number of wait-listed patients was 2,131, among which 533 (25%) were still wait-listed, 774 (36%) underwent transplantation, and 781 (37%) died on the waiting list (1). The shortage of donor lungs in Japan remains severe. One attempt to overcome this limitation is to make the most of donor lung availability through intensive management of extended-criteria donor lungs. To execute this scheme, a unique partnership between donor attending doctors and lung transplant surgeons as medical consultants (MCs) operates (4).

Since November 2002, heart transplant surgeons have been sent to procurement hospitals as MCs to assess donor organ function, provide intensive care to donors, and provide an assistance in maintaining optimal circulatory and respiratory conditions during recovery (4). Since December 2006, MCs have requested that the local doctors perform frequent phlegm aspiration with a bronchoscope, leading to a higher donor lung availability and better survival (4). In February 2011, 25 lung transplant surgeons from seven transplant centers were registered as lung MCs to specifically assess and manage donor lungs (5). In this manuscript, tasks, efficacy, and recent status of our lung MC system are reviewed.

Tasks of lung MCs and donor management

Lung MCs tasks include assessment of donor lungs, communicating the donor lung condition to the lung transplantation teams, and management of the donor lungs. Usually, the MC is dispatched to a procurement hospital between two brain-death examinations. First, the MC assesses the donor lung condition using the medical record, called a donor chart, created by the Japan Organ Transplant Network (JOTNW) coordinators. Using the donor chart, the MC can check age, arterial oxygen pressure, smoking history, history of aspiration or sepsis, prior cardiothoracic surgery, and the results of endotracheal aspirates gram staining and bacterial culture among the 10 current standard cadaveric donor lung criteria established by International Society for Heart and Lung Transplantation (ISHLT) (6). The MC then reads the chest radiographs and computed tomography (CT) images to check if the donor lungs have anatomical abnormalities in the bronchial tree, massive atelectasis, pneumonia, pulmonary edema, or pulmonary contusion due to chest trauma. Next, the MC arrives at the

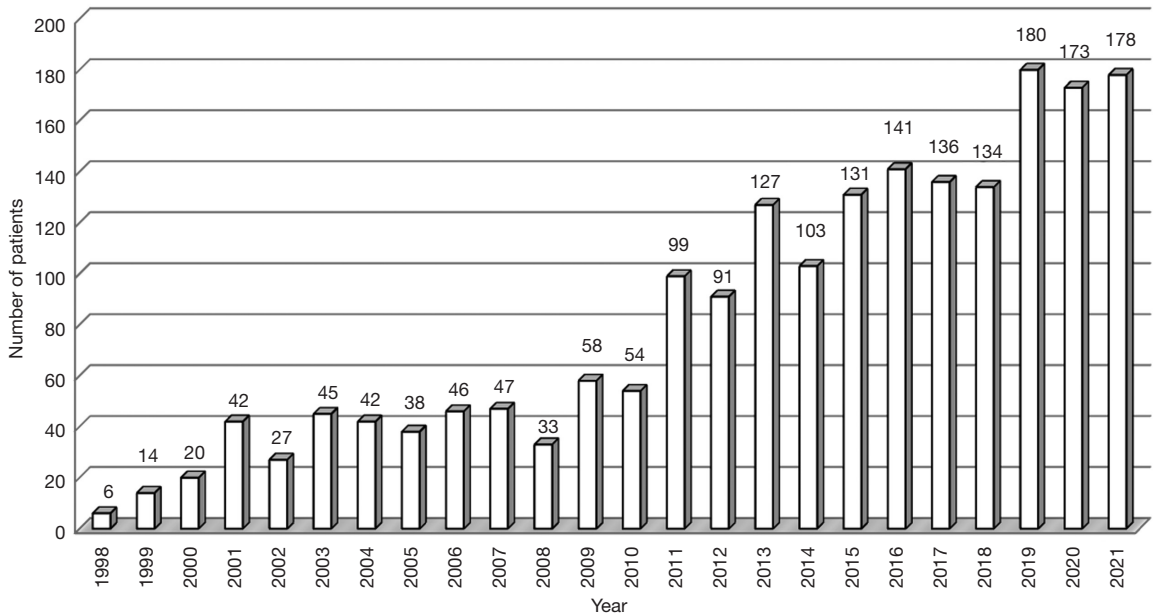

Figure 2 Annual number of newly registered candidates for cadaveric lung transplantation in Japan.

donor's bedside for chest examination via visual inspection, auscultation, and bronchoscopy. The evaluations are written on the donor chart, which communicates the condition of the donor lungs to the lung transplantation teams and retrieval surgeons. Precise information of bronchoscopic findings provided by the MC is extremely useful in helping the lung transplant team decides whether to accept a donor lung. Moreover, the MC performs phlegm aspiration with a bronchoscope, culture of the aspirates to manage with antibiotics, and present proposals for respiratory therapy, including postural drainage, mechanical ventilation, infection control, and circulatory management of donors. The ventilatory strategy is usually a lung-protective ventilation strategy, with a tidal volume of 6–8 mL/kg ideal body weight, plateau pressure less than 30 cmH_2O, end-expiratory positive pressure 8–10 cmH_2O, and FiO_2 as low as possible, in accordance with the "Manual for Patient Evaluation and Management with a View to Organ Donation and Intraoperative Management" developed by the Research Project for Transplantation Medical Infrastructure Development funded by the Ministry of Health, Labor and Welfare on March 31, 2022 (7). The donor fluid management is usually done to maintain a urine output of at least 0.5 to 1.0 mL/kg/hr, while taking care not to overfluidize the donor (7). Because hypopituitarism can occur in brain-dead patients, replacement antidiuretic hormone is administered to maintain blood pressure (7). In addition, frequent repositioning and expectoration of sputum should be performed to prevent atelectasis. Because the cough reflex disappears in brain-dead patients, periodic bronchoscopic deep suctioning of sputum is also important (7). Frequent oral care should also be remembered for the purpose of preventing ventilator-associated pneumonia. Lung MC intervention is usually performed in the evening or night of the day the first brain death examination is made; the second brain death examination is usually made the following morning, after which the procedure to confirm the recipient's will for transplantation is initiated. Since a minimum interval of 24 hours is planned between the confirmation of the recipient's willingness to undergo transplantation and the recovery operation, donor lung management is possible at least one and a half days after the lung MC intervention, and actually a little more than two days after the lung MC intervention since most recovery operations are performed before dawn.

In light of the above, the lung MCs must have a good grasp of donor lung indication criteria for transplantation based on knowledge and experience, and must be able to accurately evaluate donor lungs by tools including imaging findings and bronchoscopy. They must also have a good understanding of the characteristics of brain-dead donors and be able to recommend to the donor's attending physician measures to maintain or improve the condition of the donor lungs.

Efficacy of lung MC system

In 2014, we retrospectively reviewed the efficacy of the original lung MC system in terms of lung transplantation opportunities and outcomes (5). One-hundred and eighty-seven cadaveric lung donor candidates signed up in Japan from 1998 to 2013 were chronologically grouped into three as follows: phases I (from May 1998 to November 2006, n=44) and II (from December 2006 to January 2011, n=64) were initiated before and after the MCs requested that donor attending doctors perform frequent phlegm aspiration with a bronchoscope, respectively; and phase III (from February 2011 to January 2013, n=79) was the two-year period after the lung MCs started to participate in the donor assessment and management system. Per-donor lung utilization rate was calculated by dividing the total number of transplanted lungs by the number of donors, counting as 1 whether single or bilateral lungs donated by a single donor were transplanted. Meanwhile, per-lung value was calculated by dividing the total number of transplanted lungs by the number of donors × 2, counting 1 if only single lung was transplanted and 2 if bilateral lungs were transplanted (5). Per-donor lung utilization rates in phases I, II, and III were 61.4%, 71.9%, and 74.7%, respectively. The per-lung values in phases I, II, and III were 51.1%, 64.8% and 67.7%, respectively (P=0.03). Moreover, there was a statistically significant difference among the graft death rates due to primary graft dysfunction in phases I, II, and III, which were 13.3%, 3.6%, and 3.7%, respectively (P=0.04).

The alterations in the results of arterial gas analysis at the first and second brain death declarations as well as the tertiary evaluation by retrieval surgeons in the three phases were compared. In phases I and II, the arterial oxygen tension at the tertiary assessment was significantly lower than that at the first or second brain death examination. However, in phase III, there were no differences in the values at these three points, implying that an ideal way to manage donor lungs had been established (5). Graft survival curves in the three phases were significantly different (P=0.0408). One-year graft survival rate was 73.5% in phase I, 90.8% in phase II, which was significantly higher than that in phase I, and 86.4% in phase III (5). To investigate the reason for the difference in graft survival among the three phases, the degree of variances from standard donor lung criteria in the transplanted cases of each phase was compared. Variance from at least 1 standard donor criterion out of 10 ISHLT criteria (6) occurred in 65.5% and 69.4% of lung transplants performed in phases I and II respectively, before the intervention by the lung MCs started, whereas its frequency has become much higher (90.0%) in phase III, since the emergence of the lung MCs (P=0.0004) (5). We have shown by multivariate analysis of donor factors adjusted with recipient factors that the presence of four or more of the variances from the standard donor lung criteria constituted a significant risk factor for graft survival after lung transplantation among 173 brain-dead lung transplant cases in Japan from March 2000 to June 2013 (8). In Hoshikawa *et al.*'s study (5), the proportion of lung transplants with four or more of the extended criteria was much higher in phase III (20.0%), after the beginning of the lung MC system, than in phases I (6.9%) and II (4.8%). Finally, the frequency of decline after the retrieval surgeons arrived at the procurement hospitals were 27% in phase I, 19% in phase II, and 14% in phase III, which is statistically significantly less than in phase I (9). Taken together, the lung MC system is effective in improving lung transplantation opportunities and outcomes.

Recent status of MC system

Table 1 shows the service areas of lung MCs from seven lung transplant centers at the end of February 2011, when this consultant system started. The number of registered consultant doctors was 25. Current service areas are listed in *Table 2*. Fifty-seven consultant doctors were registered from ten lung transplant centers and Hokkaido and Nagoya Universities. Our University Hospital has been certified as the tenth lung transplant center in Japan since December 2020 and has been in charge of the lung MC service in Aichi prefecture (9). We were requested the consultant service 5 times from December 2020 to July 2021 and were surprised by the fact that most donor attending doctors had already started bronchial suctioning using bronchoscope, respiratory therapy including postural drainage, sometimes prone positioning therapy, and replacement therapy with antidiuretic hormone, all of which had been started at the request of lung MCs when this system began (9).

Recently, we analyzed 63 lung donor candidates for one year, between June 2020 and May 2021, in terms of the lung utilization rate and frequency of decline after retrieval surgeons arrived at procurement hospitals (9). The per-donor lung utilization rate was 83%, and the frequency of decline after the retrieval surgeons arrived

Table 1 Service area of lung medical consultants from each lung transplant center in February 2011

	LTx center						
	Tohoku	Dokkyo	Kyoto	Osaka	Okayama	Fukuoka	Nagasaki
Service area	Aomori	Tochigi	Kyoto	Osaka	Okayama	Fukuoka	Nagasaki
	Iwate	Ibaraki	Shiga	Hyogo	Tottori	Yamaguchi	Saga
	Akita	Gunma	Fukui	Wakaya	Shimane	Oita	Kumamoto
	Miyagi	Saitama	Ishikawa	Nara	Hiroshima	Miyazaki	Kagoshima
	Yamagata	Yamanashi	Toyama	Aichi	Kagawa	(Okinawa)	(Okinawa)
	Fukushima	Nagano	Kanagawa	Mie	Ehime		
	Niigata		Shizuoka	Gifu	Tokushima		
	Tokyo		(Hokkaido)	(Hokkaido)	Kouchi		
	Chiba						
	(Hokkaido)						

LTx, lung transplant.

Table 2 Service area of lung medical consultants from each lung transplant center in September 2022

	LTx center									
	Tohoku	Dokkyo	Chiba	Tokyo	Fujita	Kyoto	Osaka	Okayama	Fukuoka	Nagasaki
Service area	Aomori	Tochigi	Chiba	Kanagawa	Aichi	Kyoto	Osaka	Okayama	Fukuoka	Nagasaki
	Iwate	Ibaraki	Tokyo	Yamanashi		Shiga	Hyogo	Tottori	Oita	Saga
	Akita	Gunma		Nagano		Fukui	Wakaya	Shimane	Miyazaki	Kumamoto
	Miyagi	Saitama		Niigata		Ishikawa	Nara	Hiroshima	Kagoshima	(Okinawa)
	Yamagata			Tokyo		Toyama		Kagawa	Yamaguchi	
	Fukushima					Mie		Ehime	(Okinawa)	
	(Hokkaido)					Gifu		Tokushima		
						(Shizuoka)		Kouchi		

LTx, lung transplant.

at the procurement hospitals was only 8% (9). Presented for comparison, the lung utilization rate from brain-dead donors per lung, when counting a single lung as 1 and bilateral lung as 2, was 51% (1,176 lungs/2,285 lungs) in 2022 in eight European countries (Austria, Belgium, Croatia, Germany, Hungary, Luxembourg, Netherlands, and Slovenia) (10). And in the U.S., the lung utilization rate per donor was reported to be 17.6% (2,443/13,862 donors) in 2021 (11). All of this leads us to believe that the MC system in Japan is fully functioning. On the other hand, MC doctors offer MC services with a high frequency, in addition to heavy clinical practice at their own transplantation centers. One of the most important future topics of discussion is the transfer of lung MC services to experienced procurement hospitals. As mentioned earlier in this review, precise information on bronchoscopic findings provided by MCs is extremely helpful in the decision to accept or reject a donor lung. We have just released a form for the observations and description of bronchoscopic findings that can be done without a lung transplant surgeons or physicians.

The limitation of this review is that this was based only on a few studies.

Conclusions

We reviewed the tasks, efficacy, and recent status of our unique MC system for assessing and managing donor lungs in Japan. This system is expected to be effective in maintaining an extremely high lung utilization rate and favorable outcomes after lung transplantation. Furthermore, we have recently started discussing on ways to gradually transfer this service to experienced procurement hospitals without sacrificing high lung utilization rates and favorable outcomes. In the future, it would be possible to do all the fine-tuning remotely or via smartphone rather than sending out transplant surgeons physically.

Acknowledgments

The authors would like to thank all lung MC doctors, lung transplantation teams of ten certified centers in Japan, and JOTNW coordinators for their contributions to this consultant system.
Funding: None.

Footnote

Provenance and Peer Review: This article was commissioned by the Guest Editor (Masaaki Sato) for the series "Why is the Outcome Good? Secrets of Lung Transplantation in Japan" published in *Journal of Thoracic Disease*. The article has undergone external peer review.

Peer Review File: Available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-290/prf

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-290/coif). The series "Why is the Outcome Good? Secrets of Lung Transplantation in Japan" was commissioned by the editorial office without any funding or sponsorship. The authors have no other conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

References

1. Donors and Transplants Data. Japan Organ Transplant Network website. Available online: http://www.jotnw.or.jp/english/data.html.
2. Egawa H, Tanabe K, Fukushima N, et al. Current status of organ transplantation in Japan. Am J Transplant 2012;12:523-30.
3. Registry Report. The Japanese Society of Lung and Heart-Lung Transplantation website. Available online: http://www2.idac.tohoku.ac.jp/dep/surg/shinpai/pg185.html
4. Fukushima N, Ono M, Nakatani T, et al. Strategies for maximizing heart and lung transplantation opportunities in Japan. Transplant Proc 2009;41:273-6.
5. Hoshikawa Y, Okada Y, Ashikari J, et al. Medical consultant system for improving lung transplantation opportunities and outcomes in Japan. Transplant Proc 2015;47:746-50.
6. Orens JB, Boehler A, de Perrot M, et al. Pulmonary Council, International Society for Heart and Lung Transplantation. A review of lung transplant donor acceptability criteria. J Heart Lung Transplant 2003;22:1183-200.
7. Manual for Patient Evaluation and Management with a View to Organ Donation and Intraoperative Management. (Japanese) Research Project for Transplantation Medical Infrastructure Development funded by the Ministry of Health, Labor and Welfare. Available online: https://www.jotnw.or.jp/files/page/medical/manual/doc/manual202203.pdf
8. Hoshikawa Y, Ishibashi N, Okada Y, et al. Extended criteria donor lungs: a review of 173 consecutive lung transplants in Japan. Am J Respir Crit Care Med 2014;189:A5160.
9. Hoshikawa Y, Matsuda Y, Ashikari J. Current Status and Tasks of the Lung Medical Consultant System. Kyobu Geka 2022;75:259-64.

10. Annual report 2022 of the Eurotransplant international foundation. Available online: https://www.eurotransplant.org/wp-content/uploads/2023/09/Annual-Report-ET-2022.pdf
11. OPTN/SRTR 2021 Annual Data Report: Deceased Organ Donation. Available online: https://srtr.transplant.hrsa.gov/annual_reports/2021/Deceased%20Organ%20Donation.aspx#fig:DD-map-OTPD

Cite this article as: Hoshikawa Y, Matsuda Y, Ashikari J. Donor management and extremely high donor lung utilization rate in Japan. J Thorac Dis 2024;16(2):1625-1631. doi: 10.21037/jtd-23-290