Does lung allocation score maximize survival benefit from lung transplantation?

Mark J. Russo, MD, MS,[a] Berhane Worku, MD,[b] Alexander Iribarne, MD, MS,[b] Kimberly N. Hong, MHSA,[b] Jonathan A. Yang, MD,[b] Wickii Vigneswaran, MD,[a] and Joshua R. Sonett, MD[b]

Objective: The lung allocation score was initiated in May 2005 to allocate lungs on the basis of medical urgency and posttransplant survival. However, the relationship between lung allocation score and candidate outcomes remains poorly characterized. The purpose of this study was (1) to describe outcomes by lung allocation score at the time of listing and (2) to estimate the net survival benefit of transplantation by lung allocation score.

Methods: The United Network for Organ Sharing provided de-identified patient-level data. Analysis included lung transplant candidates aged 12 years or more and listed between May 4, 2005, and May 4, 2009 (n = 6082). Candidates were stratified according to lung allocation score at listing into 7 groups: lung allocation score less than 40, 40 to 49, 50 to 59, 60 to 69, 70 to 79, 80 to 89, and 90 or more. Outcomes of interest included the risk of death on the waiting list and likelihood of transplantation. The net survival benefit of transplantation was defined as actuarial median posttransplant graft survival minus actuarial median waiting list survival, where the outcome of interest was death on the waiting list or posttransplant; candidates were censored at the time of transplant or last follow-up.

Results: In the lowest-priority strata (eg, <40 and 40–49), less than 4% of candidates died on the waiting list within 90 days of listing. The median net survival benefit was lowest in the lung allocation score less than 40 (–0.7 years) and lung allocation score 90+ group (1.95 years) and highest in the 50 to 59 (3.44 years), 60 to 69 (3.49 years), and 70 to 79 (2.81 years) groups.

Conclusions: The mid-priority groups (eg, 50–59, 60–69, 70–79) seem to achieve the greatest survival benefit from transplantation. Although low-priority candidates comprise the majority of transplant recipients, survival benefit in this group seems to be less than in other groups given the low risk of death on the waiting list. As expected, both the time to transplant and survival on the waitlist are lower in the higher-priority strata (eg, 80–89 and 90+). However, their net survival benefit was likewise relatively low as a result of their poor posttransplant survival. (J Thorac Cardiovasc Surg 2011;141:1270-7)

The disparity between potential recipients and available donors demands efficient methods of organ allocation to ensure optimal use of this scarce resource. In prior years, lung allocation was based on accrued time on the waiting list.[1-3] In 1999, the US Department of Health and Human Services published the ''Final Rule,'' which required that all organ allocation systems place less emphasis on waiting time and more on medical urgency.[4] In response to the ''Final Rule,'' the organ procurement and transplantation network and the United Network for Organ Sharing (UNOS) implemented the lung allocation score (LAS) in May 2005. Under LAS, all lung transplant candidates are prioritized according to LAS, which is calculated on the basis of a multivariate model that is a weighted combination of predicted waitlist and posttransplant survival at 1 year (Appendix 1).[1]

Several studies, including those by our group, have demonstrated favorable trends in waitlist times and waitlist survival since the implementation of the LAS.[5-7] An increase in disease severity among listed patients has also been observed.[5,6,8,9] Despite this trend, acceptable posttransplant survivals have been demonstrated in the LAS era.[5-7,10] However, as previously demonstrated, as expected, posttransplant survival is inversely related to LAS at the time of transplant.[11,12]

The objectives of this study were (1) to describe outcomes by LAS at the time of listing and (2) to estimate

From the Section of Cardiac and Thoracic Surgery,[a] University of Chicago Medical Center, Chicago, Ill; and the Division of Cardiothoracic Surgery,[b] Department of Surgery, College of Physicians and Surgeons, Columbia University, New York, NY.

This work was supported in part by Health Resources and Services Administration contract 231-00-0115 and the National Institutes of Health training Grant 5T32HL007854-13 (to Drs Iribarne and Yang). The views expressed in this article are those of the authors alone and do not necessarily reflect the views or policies of the Department of Health and Human Services or the National Institutes of Health, nor does the mention of trade names, commercial products, or organizations imply endorsement by the US Government.

Disclosures: Authors have nothing to disclose with regard to commercial support.

Read at the 37th Annual Meeting of The Western Thoracic Surgical Association, Ojai, California, June 23–26, 2010.

Received for publication June 19, 2010; revisions received Dec 4, 2010; accepted for publication Dec 20, 2010.

Address for reprints: Mark J. Russo, MD, MS, Section of Cardiac and Thoracic Surgery, University of Chicago Medical Center, 5841 S. Maryland Avenue, MC 5040, Chicago, IL 60637 (E-mail: mrusso@surgery.bsd.uchicago.edu).

0022-5223/$36.00

doi:10.1016/j.jtcvs.2010.12.028

Abbreviations and Acronyms
LAS = lung allocation score
LAS-L = LAS at listing
LAS-T = LAS at transplant
UNOS = United Network for Organ Sharing

the net survival benefit of transplantation by LAS score. It has been suggested that a higher LAS score corresponds not only to an earlier likelihood of transplantation but also to a greater net *transplant benefit*.[1,13,14] However, because LAS weighs expected waiting list survival more heavily than expected posttransplant survival, it is possible that an increase in posttransplant morbidity and mortality may result in less overall benefit. This may be especially true at the highest LAS scores. To date, the relationship between LAS and candidate outcomes remains poorly characterized, and no studies have analyzed the overall *transplant benefit* associated with various LAS ranges.

MATERIALS AND METHODS

Data Collection

Use of data in this analysis is consistent with the regulations of our university's institutional review board and the UNOS Data Use Agreement. The Standard Transplant Analysis and Research Dataset were provided by UNOS (data source 020909-3). The dataset contains information collected from the UNetsm database forms, including the Transplant Candidate Registration form, Transplant Recipient Registration form, and Transplant Recipient Follow-up form. These data are the basis for the UNOS Thoracic Registry.

Study Population

The UNOS provided de-identified patient-level data for all lung transplant candidates and recipients in the United States. Analysis included lung transplant candidates aged 12 years or more and listed between May 4, 2005, and May 4, 2009 (n = 6082). Follow-up data were provided through November 19, 2009. Patients were followed from the date of listing until death, transplantation, or date of last known follow-up, and from the date of transplantation until death, retransplantation, or date of last known follow-up, which was the last day of follow-up data provided by UNOS. Recipients who underwent simultaneous transplantation of another organ (n = 10) and those with missing LAS data (n = 53) were excluded from the analysis.

To estimate survival on the waiting list across various ranges of LAS, lung transplant candidates were stratified into 7 groups according to LAS at listing (LAS-L): LAS-L less than 40, 40 to 49, 50 to 59, 60 to 69, 70 to 79, 80 to 89, and 90 or greater. To estimate posttransplant survival across various ranges of LAS, lung transplant recipients were stratified into 7 groups according to LAS at transplant (LAS-T): LAS-T less than 40, 40 to 49, 50 to 59, 60 to 69, 70 to 79, 80 to 89, and 90 or greater. For simplicity, candidates with LAS less than 40 and 40 to 49 were referred to as "low-priority"; candidates with LAS 50 to 59, 60 to 69, and 70 to 79 were referred to as "mid-priority"; and candidates with LAS 80 to 89 and 90+ were referred to as "higher-priority."

Outcome Measures

Survival analysis. For waiting list survival, candidates were followed from date of initial listing to death on the waiting list, transplant, or last follow-up. The outcome of interest was death on the waiting list; candidates were censored at the time of transplant or as lost/alive at last known follow-up.

For posttransplant graft survival, recipients were followed from date of transplant to graft failure (defined by patient death or retransplantation) or last known follow-up. The outcome of interest was graft loss; candidates were censored as lost/alive at last known follow-up. ΔLAS was defined as LAS at the time of transplant minus LAS at the time of listing.

Net survival benefit of transplantation. Net survival benefit was defined as actuarial posttransplant graft survival minus actuarial survival on the waiting list at various time points (including 90 days post-listing vs 90 days posttransplant, 1 year post-listing vs 1 year posttransplant, and 2 years post-listing vs 2 years posttransplant).

The *median* net survival benefit of transplantation was defined as actuarial median posttransplant graft survival minus actuarial median survival on the waiting list.

Data Analysis

All data were analyzed using the statistical software package Stata 9 (Stata Corp, College Station, Tex). Continuous variables were reported as means, and categoric variables were reported as frequencies. Continuous variables were compared with the Student *t* test, and categoric variables were compared with the chi-square test. All reported *P* values are 2-sided.

RESULTS

Patient Characteristics

LAS strata, including mean LAS-L ± standard deviation, LAS-T ± standard deviation (mean and median), ΔLAS (mean and median), and wait times are summarized in Table 1.

TABLE 1. Lung allocation score strata

	LAS at listing				LAS at transplant					ΔLAS			Wait time (d)		
LAS	n	%	Mean	SD	n	%	Mean	SD	Median	Mean	SD	Median	Mean	SD	Median
<40	4796	69.9%	34.1	2.6	3251	68.4%	38.8	11.7	35.3	4.65	11.2	0.52	267.0	311.4	149.5
40–49	1260	18.4%	43.9	2.7	1002	21.1%	51.1	14.3	45.8	7.26	13.9	0.06	102.0	144.4	47.0
50–59	305	4.4%	54.2	2.9	224	4.7%	61.8	13.3	57.1	7.60	13.1	0.03	58.3	85.9	26.0
60–69	145	2.1%	64.3	2.9	99	2.1%	70.5	13.4	66.6	6.23	13.3	0.04	45.9	81.0	21.0
70–79	97	1.4%	74.8	2.9	63	1.3%	76.7	10.6	75.8	1.94	10.3	0.02	43.5	108.5	15.0
80–89	154	2.2%	85.8	3.1	69	1.5%	84.0	10.4	87.5	–1.76	10.0	0.00	36.9	93.9	9.0
90+	105	1.5%	92.2	1.4	47	1.0%	90.6	6.8	92.1	–1.60	6.6	0.00	27.8	89.1	7.0
Total	6862		40.0	12.7	4755		45.3	17.1		5.18	11.84		58.3	252.79	

LAS, Lung allocation score; *SD,* standard deviation. Shows mean LAS-L ± standard deviation, LAS-T ± standard deviation (mean and median), ΔLAS (mean and median), and wait times.