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# Impact of Affect on Lung Transplant Candidate Outcomes

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### Keywords

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## INTRODUCTION

Median survival following lung transplantation has been stagnant at 5.7 years over the last decade and pales in comparison to other solid organ transplants[1]. In recent years, increased

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attention has been applied to pre-transplant candidates in an effort to identify novel extra-pulmonary prognostic factors such as frailty and body composition[2]. Physical frailty is now increasingly recognized as an important pre-transplant risk factor leading to worse pre- and post-transplant survival[3–5]. However, data in geriatrics has suggested novel psychological risk factors (so called “psychological frailty”) may also be important in predicting health related outcomes[6]. Post-transplant depression and distress at 6 months have been correlated with increased mortality in lung transplant recipients[7]. Similarly, optimism has been associated with survival in bone marrow transplant[8], and pre-transplant psychosocial vulnerability has been linked to worse post-transplant psychosocial outcomes in liver, lung, and bone marrow transplant[9]. Such factors are relatively understudied as predictors of outcomes in lung transplant candidates.

According to candidate selection guidelines, lung transplant candidates must be able to comply with complex medical regimens and demonstrate adequate psychosocial support to be listed for lung transplantation[10]. Many transplant centers utilize the Psychosocial Assessment of Candidates for Transplantation (PACT), Transplant Evaluation Rating Scale, or Stanford Integrated Psychosocial Assessment for Transplant (SIPAT) for pre-transplant psychosocial evaluation[11–14], but a range of practices exist[15]. These tools are not designed to assess factors contributing to long-term emotional well-being, such as adjustment, resilience, and optimism. While low baseline PACT scores have been associated with increased post-lung transplant mortality, increasing PACT scores in candidates with initial low baseline PACT scores does not seem to reduce mortality[16].

A clearer understanding of the factors associated with emotional well-being and psychological frailty surrounding lung transplantation is critical to selecting appropriate candidates and enhancing the benefits of a lung transplant. A balance of positive and negative affect has been described by researchers as essential to emotional health and adjustment[17] and may be a useful component in evaluating and optimizing potential lung transplant candidates. Positive affect is the extent that an individual experiences optimism and joy[18,19]. In contrast, negative affect is the extent that an individual experiences pessimism, unhappiness, anger, nervousness, and sadness[18,19]. Individuals with approximately three times more positive affect than negative affect, known as the critical positivity ratio, are able to maintain an optimal level of functioning—one that suggests resilience, flexibility, and optimism[17].

While optimism has previously been correlated with post-transplant outcomes[8,20–22], affect and the factors associated with affect have not been previously described in lung transplant candidates. Our objective in this study was to characterize affect in lung transplant candidates. We specifically examined the impact of affect on waitlist death, delisting, and post-transplant death. We also examined clinical factors to determine their association with positive affect, negative affect, and the balance of positive affect and negative affect in lung transplant candidates. Our findings provide a characterization of affect in lung transplant candidates and may serve as a building block for future interventions aimed at reducing psychological frailty and enhance emotional wellbeing in lung transplant patients.

## METHODS

This study was approved by the Mayo Clinic Institutional Review Board (IRB) under IRB 15-005378 and adheres to the ethical standards of the Declarations of Helsinki. Individual collaborating sites obtained approval from their respective IRBs.

To examine the association of adult lung transplant candidates' self-reported affect with transplant-related outcomes, consenting waitlisted candidates from six centers completed questionnaires including the Positive and Negative Affect Schedule (PANAS) annually and post-transplant. Univariate logistic regression analysis was performed to determine the association of baseline affect with outcomes of death or delisting. The details of the study are subsequently outlined.

### Study Population

Eligible participants included adult lung or heart-lung transplant candidates on the waiting list at either Mayo Clinic Rochester or Mayo Clinic Florida. In addition, adult lung transplant candidates at one of four participating United States lung transplant centers (University of Florida Gainesville; Cleveland Clinic Foundation; University of Washington; or University of Texas Health Science Center San Antonio) who consented to sharing their name and contact information with Mayo Clinic for the purpose of potential research participation were eligible. Patients were excluded if they required a medical interpreter or did not have an address in the United States. Recruitment began September 16, 2015 and ended (for the purposes of this report) on December 21, 2018.

### Questionnaire Administration

Questionnaires were mailed to all eligible participants (including Mayo Clinic and non-Mayo Clinic participants) with a mechanism for study refusal and a small token of appreciation. Non-responders were mailed a second questionnaire at one month. Continued non-responders one month after the second mailing were contacted by phone and mailed a third questionnaire, unless they chose not to participate or preferred to complete the questionnaire over-the-phone with a study coordinator. Using the same process, questionnaires were re-administered to surviving waitlisted participants annually. All participants were mailed a post-transplant questionnaire three months following the date of the lung transplant surgery. Non-responders were sent another copy of the post-transplant questionnaire every 30 days until a response was received or until post-transplant survey was mailed four times without a response. Post-transplant surveys received greater than one year following transplant were not included. Questionnaire responses were collected and entered into a secured, web-based Research Electronic Data Capture (REDCap) database[23] hosted by Mayo Clinic.

### Data Collection

Questionnaires included demographic information and relationship of the primary caregiver. Primary institutions for all participants (including Mayo Clinic and non-Mayo Clinic participants) provided reported date of transplant, date of delisting, and date of death. In addition, primary transplant diagnosis and prognostic details at the time of study enrollment

including the 6-minute walk distance (6MWD), Karnofsky score, PACT, SIPAT, and lung allocation scores (LAS) were abstracted from the electronic health record of Mayo Clinic participants. This information was not available for non-Mayo Clinic participants. If Mayo Clinic participants received a transplant during the study period, then the post-transplant hospital length of stay and number of days requiring mechanical ventilation post-transplant were also abstracted from the electronic health record.

## Survey Instruments

**PANAS:** Affect was assessed with the Positive and Negative Affect Schedule (PANAS), a previously validated 20-item scale[18] (Cronbach's α 0.86 positive affect, 0.84 negative affect). The scale consists of 10 positive and 10 negative words, rated on a Likert scale of 1 to 5 (with 1 indicating that the word applies minimally if at all and 5 indicating it applies very strongly to the respondent). Higher scores for positive words indicate more positive affect and higher scores for negative words indicate more negative affect [18]. The minimal clinically important difference was 3.8 for positive and 3.0 for negative affect scores, representing half of a standard deviation (SD). The ratio of positive-to-negative affect is termed the positivity ratio[17,24]. A positivity ratio of ≥2.9 distinguishes individuals with greater resilience to adversity, more social resources, and better optimal functioning[17].

**GAD-2.—**Generalized Anxiety Disorder Scale-2 (GAD-2) is 2-item, validated screening tool for symptoms of anxiety[25] (Cronbach's α 0.82). A score of 3 or higher is considered positive screening for anxiety with a sensitivity and specificity of 84.4% and 72.8% for generalized anxiety disorder[26].

**PHQ-2.—**The Patient Health Questionaire-2 (PHQ-2) is a validated screening tool for depression[27] (Cronbach's α 0.88). A score of 3 or higher is considered a positive screen for depression with a sensitivity and specificity of 85.7% and 69.2% for major depressive disorder, respectively[28].

**CRQ.—**The Chronic Respiratory Disease Questionnaire (CRQ) is a validated 20-item questionnaire that assesses four domains reflecting a participant's physical and emotional quality of life: shortness of breath, fatigue, emotional function, and mastery (self-efficacy) (Cronbach's α 0.82)[29]. Higher scores indicate better quality of life. The minimal clinically important difference is 0.5.

## Data Analysis

Results are presented as mean ± SD unless otherwise indicated. JMP statistical software (version 9.01, SAS, Cary, NC) or SAS version 9.4 (SAS Institute Inc.; Cary, NC, USA) was used for data analysis. Our primary predictors were positive affect, negative affect, and positivity ratio at time of study enrollment. Our primary outcomes were death on the waiting list and delisting. Our secondary outcomes included change in PANAS compared to baseline, quality of life by CRQ domains, and duration of mechanical ventilation or hospital length of stay following transplant (available for Mayo Clinic participants only). Longitudinal changes in PANAS scores were analyzed using a one-sample, paired t-test. Primary outcome, other secondary outcomes, and sub-group variables were analyzed with a

2-sided t-test. Strength of relationship between the PANAS scores and psychosocial and functional assessment tools (available for Mayo Clinic participants only) were analyzed via Pearson's correlation coefficient. Functional assessment tools included LAS, 6 MWD, and Karnofsky scores. These assessments were taken only at the time of enrollment and not followed longitudinally. Univariate logistic regression analysis was performed to determine the association of baseline positive affect, negative affect, or positivity ratio with outcomes of interest. Models were then adjusted by pre-selected variables of age, dichotomous variable of currently married or not, and dichotomous variable of having at least some college education or not. We adjusted for age, marital status and education as we believed those to be the most pertinent possible confounding variables. *P*-values ≤0.05 were considered significant; no corrections were made for multiple comparisons.

### Missing Data

Participants were only included in the analysis if a baseline PANAS was completed in its entirety. We did not analyze partially completed GAD-2, PHQ-2, or CRQ questionnaires.

## RESULTS

### Patient Demographics

During the recruitment period, 217 transplant-listed patients were sent questionnaires and 169 (77.9%) completed them. The average age at study enrollment was 58.9 ± 9.4 years. Most participants were married (71.0%), Caucasian (93.4%), and completed at least some college (62.1%) (Table 1). Primary caregivers included spouses (63.3%), parents (8.9%), adult children (7.1%), and non-spouse significant others (7.1%). Participants at Mayo Clinic tended to be younger (57.2 ± 9.28 years) than participants from other sites (61.2 ± 8.2 years; $p$=0.005). Mayo Clinic participants were also more likely to be married (77.8%) than non-Mayo Clinic participants (64.8%, $p$=0.04). A similar proportion of Mayo Clinic and non-Mayo Clinic participants received transplants, were removed from the waitlist, and died during the study.

For the 95 participants from Mayo Clinic Rochester and Florida sites: Chronic obstructive pulmonary disease (COPD) (29.5%) and pulmonary fibrosis (34.7%) were the most common reasons for transplant listing. PACT reflected acceptable or better psychosocial candidacy for transplant (mean scores 2.6 ± 0.8; N=93). Likewise SIPAT scores reflected low psychosocial risk for transplant (mean score 14.7 ± 7.9, N=62). The mean LAS and Karnofsky scores were 37.4 ± 7.7 and 62.6 ± 13.2. Pre-transplant six-minute walk distance was 1172.5 ± 325.4 feet.

As of December 21, 2018, 93 participants (55.0%) were transplanted, 17 (10.1%) were delisted, 15 (8.9%) died while on the transplant waitlist, and 44 were still waiting. At 1-year and 2-year follow-up, 31 of 34 (91.2%) and 10 of 13 (76.9%) participants still awaiting transplant completed questionnaires, respectively. Of the 93 participants transplanted, 61 (65.6%) completed a post-transplant PANAS questionnaire and median time to completion following transplant was 115 days (IQR: 92,149.5). Of the 95 participants from Mayo Clinic Rochester and Mayo Clinic Florida, 32 (33.7%) were transplanted during the study period.

Median duration of mechanical ventilation following transplant was 3.0 days [interquartile range (IQR) 0.7, 5.3] and median post-transplant hospital stay was 16.5 days (IQR 4.6, 28.4).

## Positive Affect

The mean baseline positive affect score was 36.0 ± 7.7 (mean positive affect is 33.3 ± 7.2 in healthy college students; higher positive affect score indicates greater positive affect)[19]. There were no differences in positive affect scores according to sex, marital status, relationship of primary caregiver, race, or reason for transplant. BMI and positive affect were positively correlated (0.20, $p$=0.01). Participants with an underweight BMI had a significantly lower positive affect score (27.3 ± 6.8) compared to those with normal (34.9 ± 7.8), overweight (37.5 ± 7.2), or obese (34.7 ± 8.3) BMI ($p$=0.02) (Table 2). As expected, both GAD-2 and PHQ-2 negatively correlated with positive affect scores at baseline (−0.25, $p$=0.001 and −0.43, p<0.0001, respectively). Interestingly, however, neither PACT (0.02, p=0.83) nor SIPAT (−0.18, $p$=0.17) scores correlated with positive affect. Between LAS, 6 MWD, and Karnofsky scores, only Karnofsky scores correlated with positive affect (0.20, $p$=0.04). Positive affect did not correlate with any post-transplant CRQ domain: dyspnea (0.08, $p$=0.49), fatigue (−0.01, $p$=0.92), emotional function (0.05, $p$=0.66), and mastery (0.07, $p$=0.57). Positive affect was not associated with outcomes of death on the waitlist or delisting (Table 3). After one year of waiting for transplant, 8 of 31 (25.8%) participants had a clinically significant decrease in positive affect, with a 30% decline in those still waiting at 2 years. For the overall cohort the decline in positive affect was clinically and statistically insignificant. Overtime, there was an insignificant increase in mean positive affect score among those still waiting for transplant at 1-year (+0.97 ± 5.9, $p$=0.37) followed by an insignificant decrease (−2.00 ± 5.6, $p$=0.29) at 2-years (Table 4). Positive affect was not significantly changed following transplant (−0.70 ± 9.0, $p$=0.54).

## Negative Affect

The mean baseline negative affect score was 17.3 ± 6.1 (mean negative affect is 17.4 ± 6.2 in healthy college students; higher negative affect score indicates greater negative affect)[19]. Similar to the above, there was no difference in negative affect scores according to sex, marital status, relationship with primary caregiver, or reason for transplant listing. However, Caucasian participants had a significantly higher negative affect score compared to non-Caucasian participants (17.5 ± 6.2 versus 14.5 ± 4.1; $p$=0.04). As expected, GAD-2 and PHQ-2 scores positively correlated with negative affect (0.67, $p$<0.0001 and 0.51, $p$<0.0001, respectively). Negative affect did not correlate with 6 minute walk distance (−0.18, $p$=0.08), LAS (−0.02, $p$=0.87), or Karnofsky score (0.01, $p$=0.90). Negative affect did not correlate with the post-transplant CRQ domains of dyspnea (−0.16, $p$=0.17), emotional function (−0.16, $p$=0.19), fatigue (−0.21, $p$=0.08), or mastery (−0.22, $p$=0.06).

Negative affect did not correlate with PACT (−0.05, $p$=0.63), but positively correlated with SIPAT (0.25, $p$=0.05). Negative affect was not different among participants who were transplanted (compared to those not), delisted compared to those not, or died following transplant compared to those who survived. Negative affect was higher in patients that died awaiting transplant compared to those who survived, although this did not reach statistical

significance (20.7 ± 7.3 versus 16.9 ± 5.9, respectively; $p$=0.07). (Table 2) Negative affect was associated with increased death on the waiting list by univariate analysis (OR 1.09; 95% confidence interval (CI) 1.01 to 1.18; $p$=0.029). This association remained (OR 1.10; 95% CI 1.02 to 1.20; p=0.021) despite adjustment for age, marital status, and level of education. (Table 3) After one year of waiting, 9 of 31 (29%) participants had a clinically significant increase (≥3) in the negative affect; after 2 years of waiting 5 of 10 had a clinically significant increase. Negative affect did not significantly change over time on the waitlist compared to baseline (1-year: −0.13 ± 7.9, $p$=0.93; 2-years: −2.90 ± 2.9, $p$=0.34) (Table 4). However, negative affect increased post-transplant (1.67 ± 6.3, $p$=0.04), but this did not meet the threshold of clinical significance.

### Positivity Ratio

The mean baseline positivity ratio was 2.39 ± 1.06. A minority of participants had a positivity ratio ≥2.9 indicating flourishing well-being (51 or 169, 30.2%). There was no difference in positivity ratio based on sex, marital status, relationship with primary caregiver, race, or reason for transplant listing. BMI and positivity ratio were positively correlated (0.20, $p$=0.009), but positivity ratio did not vary with BMI category (Table 2). As expected, positivity ratio was lower in participants with a positive baseline GAD-2 (1.57 ± 0.82) and PHQ-2 (1.56 ± 0.76) compared to participants with a negative baseline GAD-2 (2.54 ± 1.03, $p$<0.0001) and PHQ-2 (2.51 ± 1.04, $p$<0.0001). Positivity ratio negatively correlated with GAD-2 (−0.52, $p$<0.0001) and PHQ-2 (−0.50, $p$<0.0001). PACT, SIPAT, LAS, or Karnofsky scores; CRQ subdomains, or 6 MWD did not correlate with positivity ratio. Participants who died on the waitlist (1.82 ± 0.92) had a lower positivity ratio compared to those who survived (2.45 ± 1.05, $p$=0.02). Likewise, a higher positivity ratio was associated with decreased death on the waiting list by univariate analysis OR 0.50 (95% CI 0.26 – 0.95; $p$=0.033) and following adjustment for age, sex, and education OR 0.45 (95% CI 0.23 – 0.92; p=0.027). Positivity ratio did not significantly change while on the waiting list (1-year: +0.04 ± 0.96, $p$=0.80; 2-year: −0.70 ± 1.07, $p$=0.07) or post-transplant (−0.11 ± 1.23, $p$=0.48) compared to baseline (Table 4).

## DISCUSSION

Affect refers to the emotions we experience, our emotional expressions, and the influence of our emotions on our actions and sense of emotional well-being. Negative affect and positive affect are not dichotomous. A single experience—such as being listed for lung transplant—can generate both strong negative and strong positive emotional responses. We found that those with a higher negative affect and a lower positivity ratio had higher odds of mortality on the waitlist. This association persisted despite adjustments for potential confounding variables. Affect may therefore represent a novel risk factor for wait list mortality in lung transplant candidates.

Our findings enhance prior research demonstrating the importance of psychosocial risk factors in solid organ transplant patients[20–22,30,31]. Prior work in solid organ transplant has shown patients' dispositional optimism is associated with coping in kidney transplant [21]. Additionally, pre-transplant optimism was associated with post-transplantation quality of life

in heart transplant recipients[22]. In lung transplant specifically, prior work has demonstrated associations between psychiatric conditions (e.g. persistent depression) or psychosocial risk factors (e.g. adverse childhood events or low baseline PACT score) and post-transplant mortality[7,16,32,33]. Our findings are consistent with previous research demonstrating an association of affect with adverse events. For example, Maxwell *et al.* demonstrated that increased negative affect (as measured by PANAS) was associated with increased severity of illness in a cohort of 353 subjects suffering acute respiratory infections[34]. This finding could be particularly relevant to lung transplant candidates with limited respiratory reserve while waiting for transplantation. Reduced positive affect has also been associated with risk of death or myocardial infarction, while increased positive affect was protective against cardiac events[35,36]. Such findings lend credence to the possible association between affect and mortality in our study.

We do not have cause of death data for those who died during our study and therefore it is unclear how a negative affect or a reduced positivity might have influenced mortality on the waiting list for our cohort. However, Benzo *et al.* has demonstrated that affect is a mediator of self-management[37]. Furthermore, Kessing *et al.* previously demonstrated an association between higher positive affect and improved self-care in patients with congestive heart failure[38]. Certainly if patients' emotional well-being improves their ability to manage their chronic diseases, one could imagine it could lead to improved outcomes in lung transplant candidates.

Despite prior studies reporting decreased emotional well-being and increased depression and anxiety in lung transplant candidates[39,40], mean positive affect was higher in our study compared to college students and living kidney donors[19,41] and negative affect was similar to college students and living kidney donors[19,41]. However, we observed a mean positivity ratio (2.39 ± 1.06) lower than 2.9, the threshold previously described to distinguish individuals with optimal emotional functioning and resilience[17]. These findings indicate that many of the lung transplant candidates in our cohort were not at an optimal state of emotional well-being and interventions to improve affect may be helpful.

Affect can change, and positive affect has been the focus of prior interventions for improvement of emotional well-being in non-lung transplant populations[42]. Positive affect did not significantly change over time in our cohort, but following a lung transplant negative affect increased. This is consistent with prior studies that have demonstrated increased depression and psychological distress from the pre to post-transplant periods[43,44]. This increase in negative affect did not meet the minimally clinically significant threshold of 3.0, but may represent the emotional distress of post-transplant recovery and further reinforces the need for ongoing psychological care for patients after transplant even if post-transplant survival is not associated with pre-transplant emotional wellbeing, as in our cohort.

## Limitations

Our study had limited post-transplant deaths during the study period and as such we were likely underpowered to demonstrate an association with post-transplant mortality. Although not excluded from our study, the sickest lung transplant candidates' participation was likely limited both due to decreased capacity to complete the surveys and increased transplant

urgency with decreased waiting time. Additionally, despite our large, multi-center sample, our recruited population was fairly homogenous in regards to race and education potentially limiting the applicability of our findings to other populations. Our ability to adjust for confounding variables was limited by the number of outcome events; therefore, we were unable to adjust for disease severity factors. In addition, our surveys could not be completed by the sickest patients (e.g. who were intubated and sedated or expeditiously transplanted prior to survey completion). These factors limit drawing definitive conclusions regarding the association of affect with peri-transplant mortality. A larger study to further define the predictive ability on affect should be performed to confirm our findings.

### Implications for future research

Our study describes affect and potential associated factors in lung transplant candidates. Further understanding of how affect can be modified and whether modification improves waitlist survival are key topics for future investigation. Moreover longer duration and larger studies evaluating the impact of affect on post-transplant outcomes are needed.

## CONCLUSIONS

Affect was similar in lung transplant candidates compared to population norms. High negative affect and low positivity ratio were associated with death on the waitlist, despite adjustment for some potential confounding variables. A limitation of this finding, however, is our inability to adjust for disease severity given the small number of events during the study period. Affect may be a useful adjunctive measure for emotional well-being and may represent a future target for psychological optimization in lung transplant candidates.

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## Abbreviations:

| | |
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| **BMI** | Body Mass Index |
| **COPD** | Chronic Obstructive Pulmonary Disease |
| **CRQ** | Chronic Respiratory Disease Questionnaire |
| **GAD-2** | Generalized Anxiety Disorder Scale-2 |
| **LAS** | Lung Allocation Score |
| **PACT** | Psychosocial Assessment of Candidates for Transplantation |
| **PANAS** | Positive and Negative Affect Schedule |

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|---|---|
| **PHQ-2** | Patient Health Questionnaire-2 |
| **SIPAT** | Stanford Integrated Psychosocial Assessment for Transplant |
| **6MWD** | Six-minute Walking Distance |
| **CI** | Confidence Interval |
| **IQR** | interquartile range |
| **SD** | standard deviation |

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**Table 1:**

Cohort Characteristics

| | ***Mean (SD)*** **or n (%)** |
|---|---|
| **n** | **169** |
| **Age (yrs)** | *58.9 (9.4)* |
| **Gender** | |
| **Male** | 75 (44.4) |
| **Female** | 76 (45.0) |
| **Unknown** | 18 (10.7) |
| **BMI** | *26.2 (4.5)* |
| **Underweight (<18.0)** | 4 (2.4) |
| **Normal weight (18.0-25.0)** | 58 (34.3) |
| **Overweight (>25.0-30.0)** | 79 (46.7) |
| **Obese (>30.0)** | 21 (12.4) |
| **Unknown** | 7 (4.1) |
| **Marital Status** | |
| **Never Married** | 15 (8.8) |
| **Married** | 120 (71.0) |
| **Widowed** | 4 (2.4) |
| **Separated or divorced** | 30 (17.8) |
| **Education** | |
| **Less than high school graduate** | 14 (8.3) |
| **High school graduate** | 35 (20.7) |
| **Trade school** | 15 (8.9) |
| **Some college** | 49 (29.0) |
| **Bachelor's degree** | 29 (17.2) |
| **Advanced degree** | 27 (16.0) |
| **Race** | |
| **Caucasian** | 158 (93.4) |
| **Other** | 11 (6.5) |
| **Primary Caregiver** | |
| **Parent** | 15 (8.9) |
| **Spouse** | 107 (63.3) |
| **Significant Other** | 12 (7.1) |
| **Child** | 12 (7.1) |
| **Sibling** | 10 (5.9) |
| **Other** | 11 (6.5) |
| **Unknown** | 2 (1.2) |

| | *Mean (SD)* or n (%) |
|---|---|
| **n** | **169** |
| **Mayo Clinic Transplant Candidates** | |
| **n** | **95** |
| **Reason for Transplant** | |
| **COPD/ Emphysema** | 28 (29.5) |
| **Pulmonary Fibrosis** | 33 (34.7) |
| **Sarcoidosis** | 6 (6.3) |
| **Cystic Fibrosis** | 6 (6.3) |
| **ILD** | 10 (10.5) |
| **Pulmonary Hypertension** | 4 (4.2) |
| **Congenital Heart Disease** | 3 (3.2) |
| **Other** | 5 (5.3) |

Abbreviations: SD=Standard Deviation; YRS=years; BMI=Body Mass Index; COPD=Chronic Obstructive Pulmonary Disease; ILD=Interstitial Lung Disease

**Table 2:**

Factors associated with positive affect, negative affect, and positivity ratio

| | | Positive Affect | | Negative Affect | | Positivity Ratio | |
|---|---|---|---|---|---|---|---|
| **Variables** | **n** | **Mean ± SD** | **P-Value** | **Mean ± SD** | **P-Value** | **Mean ± SD** | **P-Value** |
| **Gender** | | | 0.57 | | 0.26 | | 0.33 |
| **Female** | 76 | 36.3 ± 7.7 | | 17.8 ± 5.6 | | 2.31 ± 1.06 | |
| **Male** | 75 | 35.5 ± 7.7 | | 16.7 ± 6.7 | | 2.48 ± 1.05 | |
| **Unknown** | 18 | | | | | | |
| **BMI** | | | 0.02* | | 0.90 | | 0.23 |
| **Underweight** | 4 | 27.3 ± 6.8 | | 20.0 ± 9.0 | | 1.70 ± 1.12 | |
| **Normal weight** | 58 | 34.9 ± 7.8 | | 17.3 ± 6.3 | | 2.33 ± 1.08 | |
| **Overweight** | 79 | 37.5 ± 7.2 | | 16.7 ± 5.4 | | 2.51 ± 1.01 | |
| **Obese** | 21 | 34.7 ± 8.3 | | 17.7 ± 6.5 | | 2.31 ± 1.78 | |
| **Unknown** | 7 | | | | | | |
| **Marital Status** | | | 0.66 | | 0.83 | | 0.98 |
| **Single** | 49 | 36.4 ± 7.2 | | 17.1 ± 5.3 | | 2.39 ± 1.06 | |
| **Married** | 120 | 35.9 ± 7.9 | | 17.3 ± 6.4 | | 2.39 ± 1.06 | |
| **Education** | | | 0.90 | | 0.93 | | 0.97 |
| **No college** | 64 | 35.9 ± 7.9 | | 17.2 ± 6.4 | | 2.39 ± 1.07 | |
| **Some college or higher** | 105 | 36.1 ± 7.6 | | 17.3 ± 5.9 | | 2.39 ± 1.05 | |
| **Race** | | | 0.21 | | 0.04* | | 0.09 |
| **Caucasian** | 158 | 35.8 ± 7.7 | | 17.5 ± 6.2 | | 2.36 ± 1.06 | |
| **Other** | 11 | 38.9 ± 7.4 | | 14.5 ± 4.1 | | 2.85 ± 0.83 | |
| **Primary Caregiver** | | | 0.83 | | 0.58 | | 0.86 |
| **Non-spouse** | 60 | 35.8 ± 7.9 | | 17.0 ± 5.2 | | 2.37 ± 1.07 | |
| **Spouse** | 107 | 36.1 ± 7.6 | | 17.5 ± 6.6 | | 2.40 ± 1.06 | |
| **Unknown** | 2 | | | | | | |
| **Reason for Transplant**** | | | 0.70 | | 0.77 | | 0.95 |
| **COPD/ Bronchiectasis** | 34 | 36.0 ± 8.0 | | 16.8 ± 6.4 | | 2.45 ± 1.01 | |
| **ILD** | 49 | 35.6 ± 8.5 | | 17.5 ± 6.8 | | 2.41 ± 1.22 | |
| **Other** | 12 | 38.9 ± 7.8 | | 16.8 ± 4.0 | | 2.52 ± 1.10 | |
| **GAD-2** | | | 0.11 | | <0.0001* | | <0.0001* |
| **Positive** | 25 | 33.7 ± 7.5 | | 24.7 ± 7.2 | | 1.57 ± 0.82 | |
| **Negative** | 140 | 36.4 ± 7.7 | | 15.9 ± 4.8 | | 2.54 ± 1.03 | |
| **Incomplete** | 4 | | | | | | |
| **PHQ-2** | | | 0.02* | | 0.0004* | | <0.0001* |
| **Positive** | 23 | 31.6 ± 9.3 | | 22.7 ± 7.2 | | .56 ± 0.76 | |

| | | Positive Affect | | Negative Affect | | Positivity Ratio | |
|---|---|---|---|---|---|---|---|
| **Variables** | **n** | **Mean ± SD** | **P-Value** | **Mean ± SD** | **P-Value** | **Mean ± SD** | **P-Value** |
| **Negative** | 143 | 36.7 ± 7.2 | | 16.4 ± 5.5 | | 2.51 ± 1.04 | |
| **Incomplete** | 3 | | | | | | |
| **Received transplant during study** | | | 0.97 | | 0.25 | | 0.24 |
| **Yes** | 93 | 36.0 ± 8.0 | | 16.8 ± 6.1 | | 2.47 ± 1.11 | |
| **No** | 76 | 36.1 ± 7.2 | | 17.9 ± 6.0 | | 2.28 ± 0.97 | |
| **Died on Waitlist** | | | 0.17 | | 0.07 | | 0.02* |
| **Yes** | 15 | 32.9 ± 8.8 | | 20.7 ± 7.3 | | 1.82 ± 0.92 | |
| **No** | 154 | 36.3 ± 6.3 | | 16.9 ± 5.9 | | 2.45 ± 1.05 | |
| **Removed from transplant list** | | | 0.29 | | 0.77 | | 0.86 |
| **Yes** | 17 | 38.1 ± 6.3 | | 17.0 ± 3.7 | | 2.36 ± 0.72 | |
| **No** | 152 | 35.8 ± 7.8 | | 17.3 ± 6.3 | | 2.39 ± 1.09 | |
| **Died Post-transplant*** ** | | | 0.94 | | 0.58 | | 0.96 |
| **Yes** | 9 | 35.9 ± 10.3 | | 15.9 ± 4.5 | | 2.51 ± 1.26 | |
| **No** | 84 | 36.2 ± 7.8 | | 16.8 ± 6.3 | | 2.49 ± 1.11 | |

Abbreviations: SD=Standard Deviation; COPD=Chronic Obstructive Pulmonary Disease; ILD=Interstitial Lung Disease; GAD-2=Generalized Anxiety Disorder Scale-2; PHQ-2=Patient Health Questionnaire-2

* Indicates statistical significance

** Includes only Mayo Clinic participants (total n=95)

*** Includes only patients that received a transplant during the study period (total n=93)

**Table 3:**

Multivariable logistic regression models univariate and adjusted for age, married, and some college education

| Endpoint | Variable | OR | p-value | Adjusted OR | Adjusted p-value |
|---|---|---|---|---|---|
| **Removed from transplant list** | Positive Affect | 1.04 | 0.23 | 1.05 | 0.24 |
| | Negative Affect | 0.99 | 0.85 | 0.99 | 0.89 |
| | Positivity Ratio | 0.97 | 0.90 | 0.96 | 0.87 |
| **Died on Waitlist** | Positive Affect | 0.94 | 0.10 | 0.95 | 0.15 |
| | Negative Affect | 1.09 | 0.03* | 1.09 | 0.05* |
| | Positivity Ratio | 0.50 | 0.03* | 0.51 | 0.06 |
| **Received transplant during study** | Positive Affect | 1.00 | 0.10 | 1.00 | 0.92 |
| | Negative Affect | 0.97 | 0.25 | 0.97 | 0.27 |
| | Positivity Ratio | 1.19 | 0.24 | 1.18 | 0.27 |

Abbreviations: OR=Odds Ratio;

*Indicates statistical significance.

**Table 4:**

Change in positive affect, negative affect, and positivity ratio over time on the waitlist and post-transplant

| | | Positive Affect | | Negative Affect | | Positivity Ratio | |
|---|---|---|---|---|---|---|---|
| | **n** | **Mean ± SD** | **p-Value** | **Mean ± SD** | **p-Value** | **Mean ± SD** | **p-Value** |
| **Baseline** | 169 | 36.0 ± 7.7 | | 17.3 ± 6.1 | | 2.39 ± 1.06 | |
| **1-year follow-up (waitlisted)** | 31 | +0.97 ± 5.9 | 0.37 | −0.13 ± 7.9 | 0.93 | +0.04 ± 0.96 | 0.80 |
| **2-years follow-up (waitlisted)** | 10 | −2.00 ± 5.6 | 0.29 | +2.90 ± 2.9 | 0.34 | −0.70 ± 1.07 | 0.07 |
| **Post-transplant** | 61 | −0.70 ± 9.0 | 0.54 | +1.67 ± 6.3 | 0.04* | −0.11 ± 1.23 | 0.48 |

Abbreviations: SD=Standard Deviation;

P-Value is a comparison from baseline mean.

* Indicates statistical significance.