Pneumonia After Kidney Transplant: Incidence, Risk Factors, and Mortality

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Abstract

Objectives: **Pneumonia is an important cause of morbidity and mortality in recipients of solid-organ transplant. We aimed to determine risk factors for development of pneumonia and associated deaths in kidney transplant recipients.**

Materials and Methods: **A retrospective review of medical records was performed for all kidney transplant recipients from December 1988, to April 2011. The diagnosis of community-acquired pneumonia was made from symptoms, clinical findings, and chest radiography. The diagnosis of nosocomial pneumonia was made according to published criteria. Laboratory and serologic tests, radiographic findings, cultures of respiratory specimens, and tissue biopsies were reviewed.**

Results: **In 406 kidney transplant recipients, there were 82 patients (20%) who had 111 episodes of pneumonia, including 49 nosocomial episodes of pneumonia (44%). Bacterial infections were the most common cause (34 episodes [31%]). In multivariate analysis, significant risk factors associated with pneumonia episodes were older age, hypertension, cardiac disease, history of acute graft rejection, and not using everolimus/mycophenolate mofetil/prednisolone protocol. There were 28 episodes that resulted in death (25%), including 20 nosocomial episodes (71%). In multivariate analysis, significant risk factors associated with death from pneumonia episodes were antibiotic use in the previous 3 months, high C-reactive protein, and low albumin. Cutoff values for increased risk of death from pneumonia included C-reactive protein > 10 mg/dL and procalcitonin > 8.8 ng/mL.**

Conclusions: **Recipients of kidney transplant may be at risk for pneumonia and associated death. Nosocomial pulmonary infections may be associated with marked morbidity and mortality in kidney transplant recipients.**

Key words: *Renal failure, Nephrology, Lung, Infection*

Introduction

Infectious complications markedly increase morbidity and mortality after kidney transplant. Sepsis and pulmonary infections are associated with high mortality.[1,2] Although effective prophylactic and immunosuppressive regimens reduce the incidence of pulmonary infections after transplant, bacterial pneumonia is the most common cause of acute respiratory failure.[3] However, little information is available about risk factors for developing infection and death in kidney transplant recipients with lower respiratory tract infection such as pneumonia.[4] The purpose of the present study was to identify the characteristics of episodes of pneumonia and risk factors for developing pneumonia and its related mortality in kidney transplant recipients.

Materials and Methods

Subjects

The study retrospectively evaluated medical records of all adult kidney transplant recipients who had kidney transplant from December 1988 to April 2011 at

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the transplant unit of a university hospital. The study protocol was approved by the hospital Institutional Review Board and was conducted in accordance with the Declaration of Helsinki.

Evaluation

In all kidney transplant recipients, records were reviewed for information about patient age, sex, and cause of end-stage renal disease; serology for *cytomegalovirus* (CMV), hepatitis B, and hepatitis C before transplant; dialysis type and duration; donor type (deceased-donor or living); history of delayed graft function, acute or chronic rejection, comorbid diseases, tuberculosis, chronic pulmonary disease, and smoking; and initial immunosuppressive regimen.

We reviewed all episodes of fever, cough, and new pulmonary infiltrate from the beginning of transplant to the day of graft failure or patient death. Pulmonary infections were defined by the presence of respiratory insufficiency of any severity, fever, and compatible radiographic findings with or without positive culture of bronchial aspirate. Community acquired pneumonia was defined as an acute pulmonary parenchymal infection associated with an acute infiltrate on chest radiography, with ≥ 2 symptoms including fever (> 38°C), hypothermia (< 36°C), rigors, sweats, new cough, change in color of respiratory secretions, chest discomfort, or dyspnea.[5] The diagnosis of nosocomial pneumonia was made according to published criteria.[6]

The clinical records of transplant recipients who had pneumonia were reviewed for clinical signs and symptoms, kidney function, laboratory tests, serology, blood and other cultures, radiographic findings, diagnostic and therapeutic procedures, other infectious events concurrent with pneumonia, the doses of immunosuppressive drugs at the time of diagnosis of infection, and the response to treatment. The severity of pneumonia was assessed with CURB-65 criteria for community acquired pneumonia;[7] based on the modified British Thoracic Society assessment tool, the CURB severity score (range, 0-4 points) was calculated as the sum of points given for each feature present (1 point given for each feature): confusion, urea > 7 mmol/L, respiratory rate > 30 breaths/min, and low blood pressure (diastolic < 60 mm Hg or systolic < 90 mm Hg).

Treatment

After diagnosis or suspicion of pneumonia, a respiratory specimen (sputum culture and/or bronchial aspirate) was collected, stained (Gram and Ziehl-Neelsen stain), and cultured for bacterial pathogens, fungi, and mycobacteria. Fiberoptic bronchoscopy and bronchoalveolar lavage were performed when there were multiple, bilateral, or diffuse pulmonary infiltrates or when there was no clinical or radiographic response after antimicrobial therapy. All microbiologic analyses of samples obtained from bronchoalveolar lavage were repeated. Serologic tests were performed for CMV, chlamydia, and mycoplasma. Bacterial pneumonia was diagnosed when blood or sputum samples showed pathogenic bacteria. Chlamydia and mycoplasma were considered pathogenic when elevated antibody titers were noted and there was clinical response to treatment. Pneumonia caused by CMV was considered when the elevated titers of CMV DNA were noted in serum or bronchoalveolar lavage specimens or in the presence of histopathological findings. *Pneumocystis carinii* pneumonia was diagnosed by immunofluorescent stain. Identification of legionella and mycobacteria was diagnostic. Fungal pneumonia was diagnosed when (1) fungal hyphae were identified by cytopathologic or histopathologic evaluation of bronchoscopic transbronchial lung biopsy or ultrasonography-guided percutaneous lung aspiration specimens; (2) positive culture findings were noted from bronchoalveolar lavage fluid, lung tissue, or blood; and (3) clinical and radiographic patterns were consistent with the diagnosis.

Surgical prophylaxis included a single dose of a cephalosporin. Other antimicrobial prophylaxis included trimethoprim/sulfamethoxazole for 6 to 9 months after transplant. Antiviral prophylaxis included acyclovir or valganciclovir. Isoniazid prophylaxis (9 mo) was given to transplant recipients who had a history of tuberculosis or positive tuberculin skin test (> 5 mm).

All patients received initial triple immunosuppressive therapy with prednisolone, an antimetabolite (mycophenolate mofetil or azathioprine), and a calcineurin inhibitor (cyclosporine or tacrolimus), or mammalian target of rapamycin inhibitor (sirolimus or everolimus). If required, antibody therapy (interleukin-2 receptor antagonist or antithymocyte globulin) also was given. All patients received intraoperative methylprednisolone

(500 mg IV) and postoperative prednisolone (1-2 mg/kg/d oral for 1 mo; then 30-40 mg/d after 1 mo; then 20-40 mg/d after 2 mo; then 10-20 mg/d after 6 mo). After the introduction of tacrolimus, mycophenolate mofetil, and interleukin-2 receptor antagonists, lower prednisolone doses were given. Calcineurin inhibitors or mammalian target of rapamycin inhibitors were given according to the physician's preference and immunologic risks. The 5 main initial immunosuppressive protocols were (1) mycophenolate mofetil/tacrolimus/prednisolone (117 patients); (2) mycophenolate mofetil/cyclosporine/prednisolone (106 patients); (3) azathioprine/cyclosporine/prednisolone (95 patients); (4) mycophenolate mofetil/everolimus/prednisolone (39 patients); and (5) mycophenolate mofetil/sirolimus/prednisolone (10 patients). Cyclosporine (8-12 mg/kg, twice daily, oral) and tacrolimus dosages (0.05-0.1 mg/kg, twice daily, oral) were adjusted to achieve target levels of 200 to 400 ng/mL (peak) and 8 to 12 ng/mL (trough) for the first 3 months and 100 to 200 ng/mL (peak) and 5 to 8 ng/mL (trough) after 3 months. Everolimus (0.75 mg, twice daily, oral) and sirolimus (loading dose, 6 mg on day 1; maintenance dose, 2 mg once daily) dosages were adjusted to achieve a target level of 3 to 8 ng/mL (trough).

Acute graft rejection was treated with methylprednisolone (1 g/d for 3 d, IV) as first-line treatment. Antithymocyte globulin was given for steroid-resistant rejection. During episodes of pneumonia, the decision to reduce immunosuppressive therapy was individualized according to the patient's clinical status. When there was a poor response to treatment or the course of pneumonia was serious and progressive, azathioprine or mycophenolate mofetil were withdrawn and, when required, the calcineurin inhibitor also was withdrawn.

Laboratory analyses

The C-reactive protein (CRP) level was measured with a kit (CardioPhase hsCRP kit, Siemens Healthcare Diagnostics, Marburg, Germany) with immunonephelometry (Behring Nephelometer Systems, Marburg, Germany). The values for healthy individuals were ≤ 3 mg/L. The normal range of CRP in the serum of 2197 healthy individuals using this assay was 1.69 mg/L. The mean intra-assay coefficient of variation was < 4.4 and interassay coefficient of variation was < 5.7. Procalcitonin levels were measured with an automatic analyzer (VIDAS B.R.A.H.M.S. procalcitonin assay, bioMérieux, Marcy L'Etoile, France). The lower limit of detection of the assay was 0.05 ng/mL. Procalcitonin levels could be determined in only 69 episodes of pneumonia.

Statistical analyses

Statistical analyses were performed with SPSS software (SPSS: An IBM Company, version 13.0, IBM Corporation, Armonk, NY, USA). Data are presented as frequency, mean, and standard deviation. The normality and homogeneity of the data were evaluated by Shapiro-Wilk test and Levene's test. Numerical variables were compared with Wilcoxon signed rank test within groups and Mann-Whitney *U* test between groups. Categorical variables were compared using the chi-square test or Fisher exact test. Logistic regression analysis was used to determine the relative risks of developing pneumonia after transplant and the risk of death in patients who had pneumonia. Only the variables with a statistically significant association in the simple logistic regression model were included in the multiple logistic regression model. Odds ratios (OR) and 95% confidence intervals (CI) were determined. Receiver operating characteristic analysis was used to determine the cutoff value for increased risk of pneumonia and death. Kaplan-Meier survival analysis was used to analyze the frequency of death from fungal and bacterial infections in transplant recipients. Statistical significance was defined by $P \leq .05$.

Results

Pneumonia episodes

Most transplant recipients were male (Table 1). There were 111 episodes of pneumonia in 82 patients (20%), including a 14 patients who had 2 episodes, 6 patients who had 3 episodes, and 1 patient who had 4 episodes of pneumonia. There were 62 community acquired episodes (56%) and 49 nosocomial episodes of pneumonia (44%). Bacterial infections were the most common cause of pneumonia (34 episodes [31%]), especially *Haemophilus influenzae, Stenotrophomonas maltophilia,* and *Pseudomonas aeruginosa*. One of the most commonly used diagnostic procedure for obtaining respiratory samples was bronchoscopy, performed in 23 episodes, with a diagnostic yield of 12 episodes (52%). In 42 episodes (38%), no organisms were isolated. Fungal infections, especially *Aspergillus*

fumigatus, were noted in 25 pneumonia episodes (23%) and viral infection in 10 pneumonia episodes (9%). Fungal cause of infection was significantly higher in nosocomial than community acquired pneumonia (nosocomial, 18 episodes [37%]; community acquired, 7 episodes (11%); $P \leq .002$). The pneumonia episodes occurred during the first month after transplant in 12 episodes (11%); from 1 to 6 months after transplant in 39 episodes (35%); and > 6 months after transplant in 60 episodes (54%).

Patients who had pneumonia episodes were more frequently male, were older, and had a higher frequency of death, obesity, diabetes mellitus, hypertension, cardiac disease, smoking, and acute graft rejection than patients who did not have pneumonia (Table 1). Patients with pneumonia received the everolimus/mycophenolate mofetil/prednisolone protocol less frequently than did patients without pneumonia (Table 1). There was no difference between patients who had or did not have pneumonia in frequency of dialysis type and duration, cause of renal failure, delayed graft function, tuberculosis, or chronic graft rejection (Table 1). The cutoff age for an increased risk of pneumonia was 34 years (sensitivity, 58%; specificity, 59%).

In multivariate analysis, significant risk factors associated with pneumonia episodes were: older age (OR=1.02; 95% CI: 1-1.05; $P \leq .03$), hypertension (OR=3.0; 95% CI: 1.5-6.2; $P \leq .003$), cardiac disease (OR=11.5; 95% CI: 2.4-56.1; $P \leq .002$), history of acute graft rejection (OR=11.3; 95% CI: 3.7-35; $P \leq .001$), and not using everolimus/mycophenolate mofetil/-prednisolone protocol (OR=10.7; 95% CI: 2.9-39.1; $P \leq .001$).

Death

Most pneumonia episodes were not associated with death (Table 2). Factors that were significantly associated with death from pneumonia episodes included earlier mean time from transplant to development of pneumonia; higher mean dose of prednisolone; higher frequency of increase in immunosuppression and antibiotic use; higher mean pulse; higher mean CURB-65 score, erythrocyte sedimentation rate, serum urea, C-reactive protein, and procalcitonin; lower mean hemoglobin and albumin; and more frequent occurrence of other infectious events (Tables 2 and 3). Cutoff values for increased risk of death from pneumonia were C-reactive protein > 10 mg/dL (sensitivity 54%and specificity 78%); procalcitonin > 8.8 ng/mL (sensitivity 41% and specificity 89%); and CURB-65 > 1 (sensitivity 88% and specificity 91%). There was no significant difference in immunosuppressive drug type, systolic or diastolic blood pressure, pathogen type, leukocyte count, creatinine, glucose, or occurrence of superinfection between patients who had death and patients who had no death from pneumonia.

In 82 kidney transplant recipients who developed pneumonia, Kaplan-Meier plots showed that there was no difference in survival between patients who

Table 1. Characteristics of Kidney Transplant Recipients With or Without Pneumonia*

Characteristic	No Pneumonia	Pneumonia	$P \leq$ †
Number of patients	324 (80)	82 (20)	—
Sex‡			
Male	189 (58)	59 (72)	.03
Female	135 (42)	23 (28)	
Age (y)§	34 ± 11	38 ± 12	.007
Donor type (deceased-donor/living)	125/199	27/55	NS
Death	41 (13)	28 (34)	.001
Creatinine at the end of the first month, μmol/L (mg/dL)	124 ± 44 (1.4 ± 0.5)	141 ± 80 (1.6 ± 0.9)	.021
Comorbid disease			
History of tuberculosis	15 (6)	5 (6)	NS
Obesity	8 (3)	6 (7)	.05
Diabetes mellitus	15 (5)	10 (12)	.02
Hypertension	72 (23)	42 (51)	.001
Cardiac disease	7 (4)	12 (15)	.001
Smoking	49 (17)	26 (32)	.005
Chronic graft rejection	34 (11)	11 (13)	NS
Acute graft rejection	23 (13)	24 (29)	.001
EVL/MMF/P protocol	36 (11)	3 (4)	.05

Abbreviations: EVL/MMF/P, everolimus/mycophenolate mofetil/prednisolone

*N=406 kidney transplant recipients. Data are reported as number, number (%), or mean ± SD.
†NS: not significant ($P > .05$).
‡Total, 248 male patients (61%).
§All patients, 35 ± 12 SD.

had bacterial (26 patients) or nonbacterial (56 patients) infection (hazard ratio = 0.63; 95% CI: 0.28-1.44; NS) or between patients who had fungal (18 patients) or nonfungal (64 patients) infections (hazard ratio = 0.68; 95% CI: 0.26-1.78; NS) (Figure 1).

Nosocomial pneumonia more frequently caused death than community acquired pneumonia (nosocomial, 20 deaths [71%]; community acquired, 8 deaths [29%]; $P \leq .001$). Death was seen more frequently in patients with nosocomial pneumonia that had longer stay than in patients with a shorter hospital stay (death, 28 ± 20 d; no death, 18 ± 15 d; $P \leq .05$). Patients who had pneumonia causing death had significantly greater oxygen demand ($P \leq .001$), positive microbial growth in cultures (blood, tracheal aspirate, and catheter) ($P \leq .004$), and other infectious events ($P \leq .004$) than patients who had pneumonia not resulting in death. Urinary tract infection (5 episodes) was the most common extrapulmonary infection in the 28 pneumonia episodes associated with death. Superinfection developed after 13 pneumonia episodes (10 bacterial and fungal; 1 viral and bacterial or fungal; 1 bacterial, fungal, and viral), but superinfection did not have greater risk of death (death, 6 episodes [21%] vs no death, 7 episodes [8%]; NS). Admission to the intensive care unit was necessary for 30 episodes of pneumonia, and 28 episodes (93%) resulted in death.

In multivariate analysis, significant risk factors associated with death from pneumonia episodes were antibiotic use in the previous 3 months (OR=19; 95% CI: 2.5-148; $P \leq .004$), high C-reactive protein (OR=1.1; 95% CI: 1.0-1.2; $P \leq .021$), and low albumin (OR=4.1; 95% CI: 1.66-1.03; $P \leq .002$).

Table 2. Characteristics Associated With Death in Kidney Transplant Recipients Who Had Pneumonia Episodes*

Characteristic	Pneumonia Episodes Without Death	Pneumonia Episodes With Death	$P \leq$ †
Number of episodes	83 (75)	28 (25)	—
Time from transplant to development of pneumonia (mo)	27 ± 36	8 ± 9	.009
Prednisolone dose (mg)‡	22 ± 22	62 ±185	.008
Increase in immunosuppression	34 (41)	20 (71)	.005
Antibiotic use in the previous 3 months	46 (55)	26 (93)	.001
Other infectious events	22 (26)	16 (57)	.005
Oxygen demand	7 (8)	28 (100)	.001
Positive microbial growth in cultures	33 (40)	20 (71)	.004
Physical examination findings			
Systolic blood pressure (mm Hg)	131 ± 19	125 ± 33	NS
Diastolic blood pressure (mm Hg)	80 ± 10	74 ± 19	NS
Pulse (beats per minute)	94 ± 14	103 ± 16	.002
CURB-65 score§	1.0 ± 0.4	2.3 ± 0.9	.001
Cause			
Bacterial infection	22 (27)	12 (43)	NS
Fungal infection	17 (20)	8 (29)	NS
Viral infection	8 (10)	2 (7)	NS
Unknown	42 (51)	13 (46)	NS

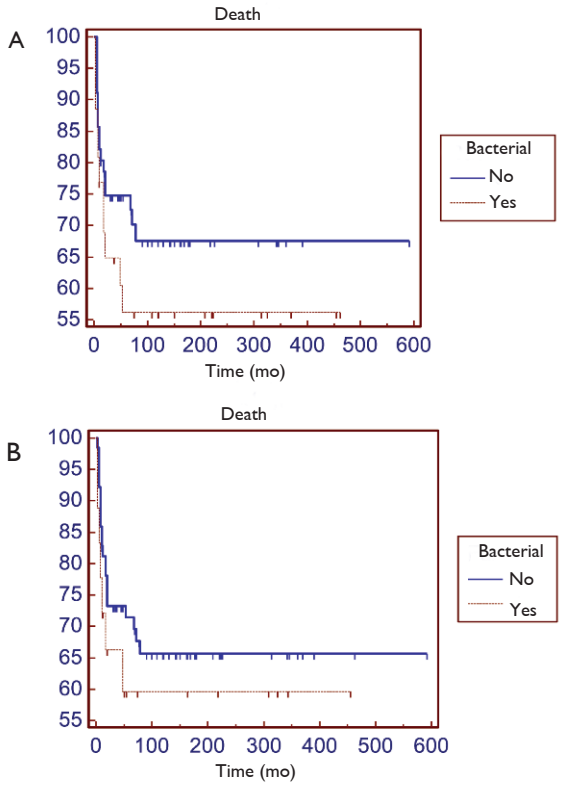
*N=111 pneumonia episodes. Data are reported as number (%) or mean ± SD.
†NS: not significant ($P > .05$).
‡Dose at time of pneumonia.
§CURB-65: confusion, urea, respiratory rate, blood pressure; for community acquired pneumonia.

Table 3. Laboratory Findings in Kidney Transplant Recipients Who Had Pneumonia Episodes Without or With Death*

Variable	Pneumonia Episodes Without Death	Pneumonia Episodes With Death	$P \leq$ †
Number of episodes	83 (75)	28 (25)	—
ESR (mm/h)	54 ± 31	75 ± 39	.02
Leukocyte count ($\times 10^{-9}$/L)	10 ± 7	9 ± 5	NS
Urea mmol/L (mg/dL)	30 ± 17 (85 ± 48)	45 ± 26 (128 ± 74)	.007
Creatinine μmol/L (mg/dL)	235 ± 170 (2.7 ± 1.9)	233 ± 171 (2.6 ± 1.9)	NS
CRP mg/L (mg/dL)	70 ± 80 (7± 8)	100 ± 70 (10 ± 7)	.008
Procalcitonin (μg/L)‡	5 ± 13	6 ± 6	.04
Hemoglobin g/L (g/dL)	110 ± 20 (11 ± 2)	90 ± 20 (9 ± 2)	.001
Albumin g/L (g/dL)	33 ± 7 (3.3 ± 0.7)	24 ± 5 (2.4 ± 0.5)	.001

Abbreviations: CRP, C-reactive protein; ESR, erythrocyte sedimentation rate
*Data are reported as number (%) or mean ± SD.
†NS: not significant ($P > .05$).
‡Without death, 52 pneumonia episodes; with death, 17 pneumonia episodes.

Figure 1. Kaplan-Meier Plots Showing Survival of Patients



Survival of patients with **(A)** bacterial and nonbacterial infections and **(B)** fungal and nonfungal infections. Survival is plotted against time from transplant until either death or the most recent follow-up.

Discussion

The present study showed that 82 of 406 kidney transplant recipients (20%) had 111 episodes of pneumonia. Respiratory tract infections comprise 8.9% of all infectious episodes after kidney transplant.[1] Although the incidence of pneumonia varied from 12% to 18% in other studies,[8,9] a recent study of 610 renal transplant recipients showed pneumonia episodes in 54 subjects (8.8%).[10] The varied use of prophylactic antibiotics may explain the differences observed in different studies about the incidence of respiratory tract infections.[1] The higher frequency of pneumonia in the present study may have occurred because the study included a longer time interval (1988 to 2011) than other studies did.

In the present study, there was a low cutoff value for age associated with increased risk of pneumonia, according to us. This may have resulted because of the younger patient population in the present study.[10] In addition, the risk of pneumonia was associated with a history of acute rejection (11.3-fold), cardiac disease (11.5-fold), hypertension (3.0-fold), older age (1.02-fold), and not using everolimus/mycophenolate mofetil/prednisolone (10.7-fold). In a previous study, kidney transplant recipients who received azathioprine and antilymphocyte globulin had a higher frequency of pneumonia than did patients who received cyclosporine.[11] Mycophenolate mofetil also may be a risk factor for infectious complications in kidney transplant recipients.[1] Although some previous studies did not evaluate everolimus,[1] CMV infections may be less frequent in patients receiving everolimus.[12] Pneumonitis is a potential adverse event associated with mammalian target of rapamycin inhibitors, and 8% to14% patients treated with everolimus for immunosuppression after solid-organ transplant may develop interstitial pneumonitis.[13]

Acute transplant rejection episodes are frequently associated with infection. The use of additional doses of immunosuppressive drugs to treat rejection may increase the risk of developing an infection. Use of methylprednisolone may cause a 1.29-fold increased risk of developing infectious episodes.[1] An important factor related to pulmonary infection is the presence of reduced renal function in infected than noninfected patients.[4] In the present population, the mean serum creatinine at the end of the first month after transplant was higher in recipients with pneumonia than it was in noninfected controls. Interventions such as dosage increase or other intensive treatments may have increased the risk of nosocomial pneumonia in some recipients who had been hospitalized for impaired renal function. Uremia may impair lung bacterial clearance.[14] Significantly more frequent bacterial infections occur in patients with delayed graft function, pretransplant diabetes, and female sex.[15] Nondiabetics, women, and recipients of grafts from living related donors may be at lower risk of developing pneumonia when treated with cyclosporine.[11]

Pneumonia-related frequency of death in the present study was similar to previous studies (15% to 29%).[8,16] Although male sex, history of diabetes mellitus, and cigarette smoking were significant risk factors for death in the univariate analysis in the present study, they were not significant risk factors in the multivariate analysis. Risk of death was increased by use of antibiotics in the previous 3 months (19-fold), low albumin (4.1-fold), and high C-reactive protein (1.1-fold). Previous antibiotic use may cause the appearance of more resistant pathogens. Serum albumin, which is commonly evaluated in hospitalized patients, may be a reliable predictor of outcome in critically ill patients who have infectious diseases.[17] Low serum albumin level also has been associated with morbidity and mortality in various diseases.[18] Low serum albumin (< 3.3 mg/dL) or high C-reactive protein (≥ 14.3 mg/dL) may be associated with death in patients with community-acquired pneumonia.[19] However, there is limited information available about the association between C-reactive protein and procalcitonin with death from pneumonia in transplant recipients. The CURB-65 criteria for community acquired pneumonia were used to assess severity of pneumonia in the present immunosuppressed patient population. These criteria were used previously only for community acquired pneumonia of immunocompetent patients. In a previous study that excluded immunocompromised patients, patients with CURB-65 score > 2 were at high risk of death.[6] In the present study, the cutoff score for an increased risk of death from pneumonia was 1, and this lower value may be associated with the immunosuppression in these patients.

In the present study, community-acquired pneumonia was more common than nosocomial

pneumonia but it had a more benign clinical course than nosocomial pneumonia. Nosocomial lung infections usually have high morbidity and mortality and frequently require treatment with invasive mechanical ventilation in intensive care units. In a study that evaluated kidney transplant recipients in an intensive care unit who had acute respiratory failure, death was associated with the severity of respiratory and hemodynamic problems, including bacterial and fungal pneumonia.[3] In the present study, there was no difference in pathogen type between pneumonia episodes associated with or without death. In a previous study, multivariate analysis showed that nosocomial pneumonia and the need for mechanical ventilation were associated with greater risk of death.[20] In the present study, nosocomial pneumonia and oxygen demand were significant risk factors for death in univariate but not multivariate analysis.

In conclusion, the present study showed that comorbid disease, history of acute graft rejection, and older age were associated with an increased risk of developing pneumonia in kidney transplant recipients. Death of patients who had pneumonia was associated with antibiotic use in the previous 3 months, high C-reactive protein, and low serum albumin.

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