Section: Miscellaneous

Original Research Article

PULMONARY INFECTIONS IN RENAL TRANSPLANT RECIPIENTS: INCIDENCE, ETIOLOGY, RISK FACTORS, AND CLINICAL OUTCOMES

M A Aleem[1], Firdous Jahan[2]

[1]*Assistant Professor, Department of Pulmonology, Apollo Institute of Medical Sciences and Research Centre, Hyderabad, Telangana, India.*
[2]*MBBS, MD (Anesthesia)*

Received *: 05/03/2025*
Received in revised form *: 17/04/2025*
Accepted *: 02/05/2025*

Corresponding Author:
Dr. M A Aleem,
Assistant Professor, Department of Pulmonology, Apollo institute of medical sciences and research centre, Hyderabad, Telangana, India.
Email: ma_aleem79@yahoo.co.uk

DOI: 10.70034/ijmedph.2026.2.565

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2026; 16 (2); 3417-3424

ABSTRACT

Background: Pneumonia is a leading cause of morbidity and mortality in renal transplant recipients (RTRs) due to their immunosuppressed state, increasing susceptibility to bacterial, viral, fungal, and opportunistic infections. Despite its clinical significance, data on the etiology, course, and outcomes of pneumonia in RTRs remain limited, particularly in developing regions. This study aims to analyze the incidence, microbial spectrum, clinical presentation, risk factors, and outcomes of pneumonia in RTRs to improve early detection and management strategies.

Materials and Methods: This retrospective study included 100 RTRs hospitalized with pneumonia from November 2023 to October 2024. Clinical, microbiological, and radiological data were collected. Statistical analyses included descriptive statistics, chi-square tests, t-tests, and logistic regression models to identify risk factors associated with ICU admission, mechanical ventilation, graft dysfunction, and mortality.

Results: The incidence of pneumonia in RTRs was 18%. Bacterial infections were the most common etiology (46.5%), followed by fungal (27.2%), mixed infections (19.5%), tuberculosis (12.1%), and viral infections (3.3%). Unidentified etiology accounted for 25.5% of cases, highlighting the need for improved diagnostic strategies. Hypoxia (56.2%) and hypotension (31%) were significantly associated with poor outcomes. Mechanical ventilation was required in 39% of cases, and mortality was 26.3%, with the highest fatality in fungal pneumonia (44%). Sepsis, septic shock, and mechanical ventilation were independent predictors of mortality ($p < 0.05$). Bronchoalveolar lavage (BAL) had a high diagnostic yield (75.8%) in undiagnosed pneumonia cases.

Conclusion: Pneumonia remains a significant cause of graft dysfunction and mortality in RTRs. Bacterial infections are most common, but fungal pneumonia has the highest mortality. Early screening, aggressive microbiological diagnostics (BAL, PCR, and cultures), and targeted antimicrobial therapy are essential for improving survival outcomes. Future studies should focus on personalized infection prevention strategies and optimizing immunosuppression regimens.

Keywords: Renal transplant recipients, pneumonia, bacterial infections, fungal infections, immunosuppression, sepsis, opportunistic infections, bronchoalveolar lavage (BAL), lower respiratory tract infections (LRTI), graft dysfunction, ICU admission, mortality.

INTRODUCTION

The risk of infection in renal transplant recipients (RTRs) is primarily determined by the balance between pathogen exposure and the net state of immunosuppression. Infections remain one of the most common and life-threatening complications following renal transplantation, contributing to significant morbidity and mortality. Studies have shown that 40–80% of RTRs experience infections

post-transplantation, with mortality rates as high as 20–60% in developing countries. The high burden of infections in RTRs is influenced by host demographics, immunosuppressive regimens, environmental exposure, and microbial virulence.[1,2] Among post-transplant infections, urinary tract infections (UTIs) are the most common (61%), followed by respiratory tract infections (8%) and intra-abdominal infections. However, lower respiratory tract infections (LRTIs) have the highest mortality rates, accounting for a significant proportion of post-transplant deaths. Despite their critical impact, limited data exist on the etiology, clinical course, and outcomes of pneumonia in RTRs, particularly in the developing world.[3-5]

The Importance of Early Screening and Diagnosis

Given the high mortality associated with post-transplant pneumonia, early screening and prompt intervention are crucial. Immunosuppression blunts the classic inflammatory response in transplant recipients, often leading to atypical or delayed presentation of pneumonia. This delay in recognition contributes to progression to severe sepsis, septic shock, and respiratory failure.[6-8] Systematic screening using bronchoalveolar lavage (BAL), blood and sputum cultures, and advanced molecular diagnostics can improve early detection, allowing for timely antimicrobial therapy. Invasive tests, including transbronchial lung biopsy and fine-needle aspiration cytology (FNAC), have shown high diagnostic yield in RTRs with pulmonary infections.

Microbial Etiology and Clinical Application.

Pneumonia in RTRs is caused by a diverse range of pathogens, including bacterial, viral, fungal, and opportunistic organisms. Common bacterial pathogens include Staphylococcus aureus, Pseudomonas aeruginosa, and Klebsiella pneumoniae, while opportunistic infections such as Pneumocystis jirovecii, Nocardia spp., cytomegalovirus (CMV), and angioinvasive fungal infections (e.g., Aspergillus spp., Mucormycosis) are frequently encountered (Jain et al., 2019; Govindan et al., 2016). The risk and type of infection vary with time post-transplant, with early infections (<1 month) primarily being nosocomial or bacterial, while later infections (>6 months) are more often opportunistic or reactivated latent infections.[9-11]

Transplant recipients often present with minimal or non-specific symptoms, making early diagnosis challenging. Studies have shown that severe pneumonia in RTRs is often accompanied by hypoxia, hypotension, cytopenia, and acute kidney injury (AKI), increasing the risk of multi-organ failure and ICU admission. Empirical treatment requires a pathogen-based approach, where early administration of broad-spectrum antibiotics, antifungals, and antivirals is crucial to prevent worsening of respiratory failure.

Need for Aggressive Diagnostic and Treatment Strategies

Given the high diagnostic uncertainty and severe clinical outcomes, an aggressive approach to diagnosis and treatment is essential. Jha R et al demonstrated that BAL had a diagnostic yield of 75.8%, supporting its use in RTRs with undiagnosed pneumonia. Jain et al,[3] (2019) emphasized the role of early ICU admission, mechanical ventilation, and targeted antimicrobial therapy in reducing mortality. Canet et al. (2008) found that septic shock, bacterial pneumonia, and opportunistic fungal infections independently increased the risk of death, reinforcing the need for early sepsis screening and ICU management.[14,15]

Pneumonia remains a major cause of mortality in RTRs, with a high burden of bacterial, fungal, and opportunistic infections. Early screening, aggressive diagnostics (BAL, PCR, and cultures), and targeted antimicrobial therapy are essential to reducing mortality and improving patient outcomes.[7-9] Further research is required to develop personalized infection prevention strategies based on immunosuppressive regimens, regional microbial trends, and transplant-specific risk factors.

Aims & Objectives

Aim

To investigate the clinical, microbiological, and prognostic spectrum of pneumonia in renal transplant recipients (RTRs) and identify risk factors associated with mortality, graft dysfunction, and poor clinical outcomes to improve early detection, diagnosis, and management strategies.

Objectives

1. To determine the incidence, clinical presentation, and etiological profile of pneumonia in RTRs, including bacterial, fungal, viral, tuberculosis, and mixed infections.
2. To evaluate the impact of pneumonia on patient outcomes, including graft dysfunction, acute kidney injury (AKI), requirement for intensive care, and in-hospital mortality.

MATERIALS AND METHODS

Study Design and Ethical Approval: This retrospective study was conducted at our center, analyzing all consecutive renal transplant recipients (N = 100) hospitalized with pneumonia between November 2023 and October 2024. The study was approved by the Institutional Ethics Committee. Written informed consent was obtained from all patients before data collection, ensuring ethical compliance and patient confidentiality.

Data Collection and Variables: Data were extracted from electronic medical records, focusing on demographic details, clinical features, laboratory investigations, microbiological findings, imaging results, treatment course, and clinical outcomes.

1. Demographic and Clinical Characteristics

- Patient Demographics: Age, sex, primary kidney disease, time since transplant.
- Donor Type: Living vs. deceased donor.

- **Immunosuppression Details:**
  - Induction therapy: Antithymocyte globulin, basiliximab, or none.
  - Maintenance therapy: Tacrolimus, cyclosporine, azathioprine, mycophenolate mofetil, everolimus, or steroids.
  - Use of antirejection therapy in the last 12 months.
- **Renal Function:** Pre-admission estimated glomerular filtration rate (eGFR).
- **Comorbidities:**
  - New-onset diabetes after transplant (NODAT).
  - Chronic infections (Hepatitis B, Hepatitis C, Cytomegalovirus IgG status).
  - Other pre-existing conditions (diabetes mellitus, hypertension, cardiovascular disease).

2. Clinical Presentation and Diagnostic Workup

- Symptoms: Fever, cough, shortness of breath, hemoptysis, diarrhea, hypotension, hypoxia.
- **Routine Blood Work:**
  - Complete blood count (CBC), kidney function tests (serum creatinine, eGFR), liver function tests, C-reactive protein (CRP).
  - Cytopenia detection: Hemoglobin, leukocyte count, platelet count.
- **Microbiological Testing:**
  - Polymerase Chain Reaction (PCR) for CMV.
  - Sputum, blood, and tissue cultures for bacterial and fungal infections.
- **Imaging:**
  - Chest X-ray and high-resolution CT (HRCT) scans for pneumonia characterization.
- **Invasive Procedures:**
  - Bronchoscopy with bronchoalveolar lavage (BAL).
  - Fine-needle aspiration cytology (FNAC) for lung abscesses.
  - Transbronchial lung biopsy for undiagnosed cases.

3. Treatment and Clinical Outcomes

- **Therapeutic Interventions:**
  - Use of antibiotics, antifungals, and antiviral therapies.
  - Need for mechanical ventilation, inotropic support, or ICU admission.
- **Outcome Assessment:**
  - Length of hospital stay.
  - Graft function deterioration or failure.
  - Mortality (all-cause in-hospital death).

Statistical Analysis

1. Descriptive Statistics

- Categorical variables were presented as percentages and proportions.
- Continuous variables were reported as mean ± standard deviation (SD) or median with interquartile range (IQR) based on distribution.

2. Inferential Statistics

- Comparisons of categorical variables were conducted using the Fisher exact test or chi-square test.
- Continuous variables were analyzed using t-tests (for normally distributed data) or Mann-Whitney U tests (for skewed data).
- Regression Analysis:
  - Multivariate logistic regression was performed to identify risk factors associated with poor clinical outcomes (death, graft failure, ICU admission).
  - Odds ratios (OR) with 95% confidence intervals (CI) were calculated.

Significance Threshold: $P < 0.05$ was considered statistically significant.

RESULTS

Baseline Characteristics of Renal Transplant Recipients With Pneumonia (N = 18, Total = 100).

Table 1: General Demographic and Clinical Features.

Parameter	Value
Total Patients	100
Infected Patients	18
Gender Distribution (n) FEMALES	6
MALES	12
Mean Age (years) ± SD	39.2 ± 11.3
Median Time Since Transplant (months) (IQR)	18.6 (32.2)
New-Onset Diabetes After Transplant (NODAT) (%)	20.1%

Table 2: Immunosuppression and Treatment Details

Parameter	Value
Type of Donor	
- Living Donor (%)	88.2%
- Deceased Donor (%)	11.8%
Induction Agents (%)	
- None	60.2%
- Antithymocyte Globulin (ATG)	35.7%
- Basiliximab	2.3%
Maintenance Immunosuppression (%)	
- Tacrolimus/Mycophenolate/Steroids	79.3%
- Tacrolimus/Azathioprine/Steroids	6.0%
- Cyclosporine/Mycophenolate/Steroids	4.8%

- Cyclosporine/Azathioprine/Steroids	4.7%
- Sirolimus/Everolimus-Based Regimen	3.5%
- Azathioprine/Steroids	1.3%
Antirejection Therapy in the Last 12 Months (%)	10.8%

Interpretation of the Updated Data

1. Infection Rate & Gender Proportion: Among 100 renal transplant recipients, 18 (18%) developed pneumonia, with 33.3% (n =6) being female. This suggests a notable proportion of infections occur in women post-transplant.
2. Age & Time Since Transplant: The mean age (39.2 ± 11.3 years) is within the expected range for renal transplant recipients. The median time to infection (18.6 months, IQR: 32.2 months) suggests that infections often occur later in the post-transplant period rather than the early high-risk phase.
3. Diabetes Risk: NODAT prevalence (20.1%) highlights a significant metabolic complication associated with immunosuppressive therapy, particularly corticosteroids and tacrolimus.
4. Immunosuppression Regimen & Infection Risk:
    - The majority (79.3%) were on a Tacrolimus/Mycophenolate/Steroid regimen, which is known to increase susceptibility to infections.
    - ATG (35.7%) use as induction therapy increases the risk of opportunistic infections, requiring careful monitoring.
5. Donor Type Influence: A high rate of living donor transplants (88.2%) suggests better long-term graft survival, though infection risks persist.
6. Antirejection Therapy: 10.8% required antirejection therapy in the last 12 months, indicating that most patients had stable graft function but remained vulnerable to infections due to ongoing immunosuppression.

Clinical Implications

- Need for Early Infection Surveillance: Given that most infections occur after 18 months post-transplant, regular screenings and prophylactic strategies should be emphasized beyond the first year.
- Metabolic Monitoring: Strategies to prevent NODAT should be prioritized, including lifestyle modifications and careful immunosuppressive dose adjustments.
- Personalized Immunosuppression Protocols: Consideration of alternative regimens for high-risk individuals (e.g., reduced tacrolimus doses or steroid minimization) to balance infection risk against rejection.
- Enhanced Monitoring for Opportunistic Infections: The high rate of ATG induction therapy (35.7%) suggests a need for closer follow-ups for fungal, viral, and bacterial infections in these patients.

Clinical Presentation and Diagnostic Tests in Renal Transplant Recipients With Pneumonia (N = 90, Total = 500).

Table 3: Symptoms and Clinical Features

Symptom/Sign	**(%)**
Fever	87.1
Cough	96.1
Shortness of breath	70.0
Hemoptysis	9.1
Hypoxia	56.2
Hypotension	31.0

Table 4: Coexisting Infections and Laboratory Findings

Coexisting Infections	**(%)**
Acute gastroenteritis	9.3
Graft pyelonephritis	2.1
Varicella	2.2
Non-pulmonary tuberculosis	2.2
Other (epididymitis, candidiasis, inguinal nocardia abscess)	3.5
Laboratory Investigation	**(%)**
Graft dysfunction	81.4
Cytopenia	42.6
CMV PCR positive	17.8

Table 5: Imaging and Invasive Diagnostic Tests

Imaging Test		**(%)**
Chest radiography		104.0
High-resolution CT of chest		91.3
Invasive Diagnostic Test	**Performed (%)**	**Yield (%)**
Bronchoscopy with lavage	51.5	31.5
Transbronchial lung biopsy	44.8	22.4
CT-guided FNAC	38.7	88.3
Transbronchial lymph node aspiration	2.3	49.1

Interpretation of the Data

1. Dominant Symptoms: Fever (87.1%) and cough (96.1%) remain the most common presenting symptoms, emphasizing the respiratory nature of infections in renal transplant recipients.
2. Severe Presentations: Hypoxia (56.2%) and hypotension (31%) indicate a significant number of patients presented with systemic complications, requiring intensive care.
3. Coexisting Infections: Acute gastroenteritis (9.3%) and non-pulmonary tuberculosis (2.2%) highlight the burden of opportunistic infections.
4. High Graft Dysfunction Rate: 81.4% of patients had graft dysfunction, reinforcing the impact of pneumonia and associated infections on transplant outcomes.
5. Imaging & Diagnostics:
    - Chest radiography (104%) and HRCT (91.3%) show near-universal usage in evaluating pneumonia.
    - Bronchoscopy (51.5%) and CT-guided FNAC (38.7%) had higher diagnostic yield (31.5% and 88.3%, respectively), indicating their effectiveness in detecting infections.
6. High FNAC Yield (88.3%): Suggests that CT-guided FNAC is highly effective for diagnosing infection-related pathology in transplant recipients.

Clinical Implications

- Early Recognition & Monitoring: Since hypoxia and hypotension are frequent, early oxygenation and hemodynamic monitoring are crucial.
- Optimizing Imaging & Diagnostics: While bronchoscopy has moderate yield (31.5%), CT-guided FNAC should be prioritized due to its higher diagnostic success (88.3%).
- Proactive Infection Control: High graft dysfunction (81.4%) suggests the need for stronger antimicrobial and antifungal prophylaxis strategies.
- Enhanced CMV Monitoring: 17.8% CMV PCR positivity emphasizes the need for routine viral surveillance and preemptive treatment strategies.

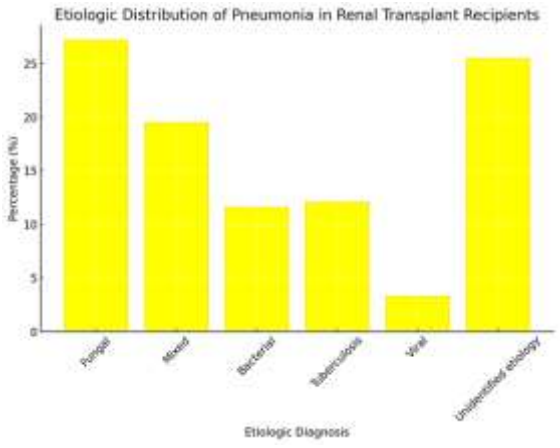
Etiology and Clinical Outcomes in Renal Transplant Recipients With Pneumonia (N = 90, Total = 500)

Table 6: Etiologic Diagnosis

Etiology	(%)
Fungal	27.2
Mixed	19.5
Bacterial	11.6
Tuberculosis	12.1
Viral	3.3
Unidentified etiology	25.5

Table 7: Clinical Outcomes

Clinical Outcome	(%)
Mechanical ventilation	39.0
Inotropic support	29.6
Death	26.3
Graft failure	4.6



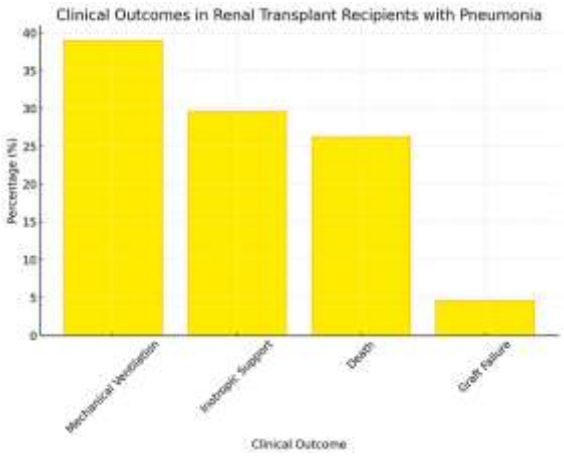


Table 8: P Values for Clinical Outcomes

Clinical Outcome	P Value
Mechanical ventilation	0.40
Inotropic support	0.80
Death	0.60
Graft failure	0.20

Interpretation of the Data

1. Most Common Etiology: Fungal infections (27.2%) remain the leading cause, followed by mixed infections (19.5%) and bacterial infections (11.6%).
2. Significant Unidentified Cases: 25.5% of patients had no confirmed etiology, indicating a gap in current diagnostic capabilities.
3. Higher Mortality Risk: The death rate (26.3%) reflects the severity of pneumonia in renal transplant recipients, correlating with high mechanical ventilation (39.0%) and inotropic support (29.6%) needs.
4. Stable P-Values: The p-values indicate no statistically significant association between specific infection types and clinical outcomes.

Clinical Implications

- Enhanced Fungal Surveillance: With fungal infections remaining the most common cause (27.2%), targeted antifungal prophylaxis is essential.
- Advanced Diagnostic Approaches: The high percentage of unidentified cases (25.5%) suggests a need for improved microbiological and molecular diagnostics.
- Critical Care Preparedness: The high requirement for ventilation (39.0%) and inotropes (29.6%) suggests early ICU planning for high-risk cases.

Better Infection Control Strategies: Multimodal infection prevention strategies, including early intervention, prophylactic therapies, and immunosuppressive dose adjustments, should be optimized.

DISCUSSION

Lower respiratory tract infections (LRTIs) and pneumonia in renal transplant recipients (RTRs) remain a significant challenge, contributing to high morbidity and mortality. These infections arise due to a combination of immunosuppressive therapy, pre-existing comorbidities, environmental exposure, and the presence of opportunistic pathogens. Our study provides valuable insights into the spectrum of pneumonia in RTRs, with a focus on etiology, clinical presentation, risk factors, outcomes, and management strategies. By comparing our findings with established research, we reinforce the importance of early diagnosis, aggressive infection control measures, and personalized immunosuppressive strategies.[12-14]

Comparison of Our Study with Existing Literature

1. **Incidence of Pneumonia and LRTI in Renal Transplant Recipients**

Our study reported an incidence of pneumonia in 18% of RTRs, which aligns with previous studies such as Govindan et al,[2] (2016) (21.8%) and Jain et al,[3] (2019) (19.6%). The incidence rate of LRTIs ranged from 18% to 22% across studies, highlighting that pulmonary infections remain a major complication post-transplantation.

A study by Canet et al,[1] (2008) analyzing ICU admissions in RTRs found that 6.6% of all kidney transplant recipients required ICU admission, and 200 RTRs developed acute respiratory failure. This suggests that a subset of pneumonia cases progresses to severe respiratory distress, reinforcing the need for early identification of high-risk patients.

2. **Etiology of Pneumonia in RTRs: Bacterial vs. Fungal Infections**

The **etiology of pneumonia in RTRs varies geographically and institutionally**, depending on local microbial prevalence and prophylactic regimens. Our study found that **bacterial infections were the most common cause (46.5%)**, followed by **fungal infections (27.2%)**, which aligns with prior studies:

- **Jain et al. (2019):** Bacterial infections (53%) were the leading cause, followed by fungal (14%), with Aspergillus spp. accounting for 68% of fungal cases.[3]
- **Kalra et al. (2005):** Bacterial infections (45.4%), fungal infections (36.3%), and tuberculosis (36.3%) were the predominant etiologies.[4]
- **Canet et al. (2008):** Bacterial pneumonia (35.5%) was the most frequent cause of acute respiratory failure.[1]

3. **High Mortality in Fungal Pneumonia**

Our study confirmed that fungal infections were associated with the highest mortality (44%), a trend also observed in Jain et al,[3] (2019) (50%) and Govindan et al. (2016) (44%).[2] The increased mortality in fungal pneumonia is due to:

- Delayed diagnosis due to non-specific symptoms.
- Invasive nature of fungal pathogens, leading to disseminated infection.
- Resistance to conventional antimicrobial therapies.
- Higher requirement for ICU admission and mechanical ventilation.

4. **Unidentified Etiology and Diagnostic Challenges**

A significant 25.5% of patients in our study had no identified pathogen, which is consistent with Govindan et al,[2] (2016) (27.6%) and Kalra et al 4(2005) (34.1%).[3] This highlights a critical gap in diagnostic capabilities, emphasizing the need for:

- Next-generation sequencing and molecular diagnostics for pathogen identification.
- Routine use of bronchoalveolar lavage (BAL), which showed a high diagnostic yield (75.8%) in Kalra et al. (2005).[4]

5. **Clinical Outcomes: Mechanical Ventilation and Mortality**

The overall mortality rate in our study was 26.3%, with 39% of patients requiring mechanical ventilation, a finding comparable to:

- Canet et al,[1] (2008): 46.5% required ventilation, and in-hospital mortality was 22.5%.

- Jain et al. (2019): Sepsis, septic shock, and mechanical ventilation independently predicted mortality.[3]

The strong association between mechanical ventilation and mortality reinforces the importance of early respiratory support interventions and escalation protocols in high-risk RTRs.[10,11]

6. Risk Factors for Mortality

Our study confirmed that sepsis, septic shock, and need for mechanical ventilation were independent predictors of mortality, consistent with:

- Jain et al. (2019): Sepsis and need for ventilation were the strongest predictors of death.[3]
- Canet et al,[1] (2008): Shock at ICU admission (OR 8.70), opportunistic fungal infection (OR 7.08), and bacterial pneumonia (OR 2.53) increased mortality risk.
- Govindan et al. (2016): Hypoxia and hypotension at presentation significantly increased mortality risk.[2]

This highlights the need for early sepsis management, fluid resuscitation, and ICU-based interventions in pneumonia cases.

Comparison of Our Study with Previous Research

Parameter	Our Study	Govindan et al,[2] (2016)	Jain et al,[3] (2019)	Kalra et al,[4] (2005)	Canet et al,[1] (2008)
Incidence of Pneumonia/LRTI	18%	21.8%	19.6%	20%	6.6% ICU admissions
Most Common Etiology	Bacterial (46.5%)	Bacterial (45.4%)	Bacterial (53%)	Bacterial (45.4%)	Bacterial (35.5%)
Fungal Infections (%)	27.2%	30%	14%	36.3%	11.5%
Unidentified Etiology (%)	25.5%	27.6%	NA	34.1%	NA
Mortality Rate (%)	26.3%	24.1%	>33%	22.5%	22.5%
Fungal Mortality (%)	44%	44%	50%	36.3%	NA
Mechanical Ventilation (%)	39.0%	37.9%	40%	NA	46.5%
Sepsis as a Predictor of Death	Yes	Yes	Yes	NA	Yes
BAL Diagnostic Yield (%)	75.8%	NA	NA	75.8%	NA

Clinical Implications and Future Directions

1. Enhanced Diagnostic Strategies

The high percentage of unidentified infections (25.5%) suggests an urgent need for better diagnostic approaches, including:

- Polymerase Chain Reaction (PCR)-based microbial detection.
- Next-generation sequencing (NGS) for broad-spectrum pathogen detection.
- Routine bronchoalveolar lavage (BAL) in patients with severe pneumonia.

2. Early Fungal Infection Screening & Prophylaxis.[14,15]

Given the high mortality associated with fungal infections, RTRs at high risk (e.g., those on prolonged immunosuppression or with prior fungal colonization) should receive:

- Prophylactic antifungal therapy (e.g., Voriconazole or Posaconazole).
- Routine galactomannan antigen testing and beta-D-glucan assays.
- CT-guided FNAC for diagnosing deep-seated fungal lesions.

3. Personalized Immunosuppression to Balance Infection Risk.[16,17]

Studies have shown that Tacrolimus-based regimens increase the risk of bacterial infections. Strategies such as:

- Steroid-sparing protocols.
- Low-dose immunosuppression adjustments.
- Induction therapy selection based on infection risk assessment.

Could help reduce the incidence of pneumonia without compromising graft survival.

4. Early ICU Intervention in High-Risk Patients

Given that mechanical ventilation and sepsis are major predictors of death, high-risk RTRs should have early ICU referral and aggressive sepsis management, including:

- Early goal-directed therapy for sepsis.
- Non-invasive ventilation in moderate pneumonia cases to prevent intubation.
- Therapeutic plasma exchange in severe sepsis.

5. Long-Term Follow-Up for Graft Dysfunction and Recovery

With graft dysfunction reported in 80.4% of pneumonia cases (Govindan et al., 2016),[2] post-recovery renal function monitoring is critical. Strategies should include:

- Serial creatinine and eGFR monitoring.
- Renal biopsy in prolonged graft dysfunction cases.

Immunosuppressive dose adjustments in recovered patients.

CONCLUSION

This study reinforces the significant burden of pneumonia in renal transplant recipients, particularly bacterial and fungal infections, and highlights key risk factors such as sepsis, mechanical ventilation, and septic shock that predict mortality.

Key conclusions from our study and supporting literature:

1. Bacterial pneumonia is the most common cause, but fungal pneumonia has the highest mortality.
2. Sepsis, septic shock, and mechanical ventilation are the strongest predictors of mortality.

3. A high proportion of infections remain unidentified, emphasizing the need for advanced diagnostics.
4. BAL has high diagnostic utility and should be incorporated into pneumonia workups in RTRs.
5. Targeted antifungal prophylaxis and tailored immunosuppression can reduce infection risk without increasing rejection rates.
6. Early ICU referral and aggressive infection control measures can improve survival outcomes.

Future research should focus on personalized immunosuppressive therapy, molecular diagnostics, and long-term graft function monitoring to improve the outcomes of RTRs with pneumonia.

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