# Early Bacterial Pneumonia After Hepatic Transplantation: Epidemiologic Profile

J. Prieto Amorin*, M. Lopez, K. Rando, J. Castelli, and J. Medina Presentado

Programa Nacional de Trasplante Hepático, Unidad Bi-Institucional de Enfermedades Hepáticas Compleja (Hospital Militar, Hospital de Clínicas), Cátedra de Enfermedades Infecciosas, Facultad de Medicina Montevideo, UdeLaR, Montevideo, Uruguay

## ABSTRACT

**Background.** Postoperative pulmonary complications are major cause of morbidity and mortality in patients receiving liver transplantation (LT), particularly bacterial pneumonia occurring within the first 100 days after transplantation. Our aim in this study was to determine the incidence, microorganisms involved, associated factors, and morbidity of bacterial pneumonia presenting in the first 100 days posttransplant.

**Methods.** We performed a cohort study in which patients receiving liver transplantation were included prospectively in our national database (Database of Infections in Transplantation of Solid Organs). The study period was from July 14, 2009 to July 24, 2015.

**Results.** One hundred six patients were transplanted during the 6-year period. We documented 9 bacterial pneumonia cases with an incidence of 8.5 per 100 patients; 2 patients had hospital-acquired pneumonia (HAP) and 7 had ventilator-associated pneumonia (VAP). In 4 of the 9 bacterial pneumonia cases, patients presented with bacteremia. Eleven microorganisms were isolated these 9 patients. Microbiologic diagnosis methods included 5 cases of alveolar bronchoalveolar lavage (BAL), 1 case of BAL and pleural fluid puncture, 1 case of pleural fluid puncture, and 1 case through sputum study. Of the 11 isolated organisms, 9 corresponded to Gram-negative bacilli (GNB): *Klebsiella* spp, n = 3; *Acinetobacter baumannii*, n = 4; *Morganella morganii*, n = 1; and *Pseudomonas aeruginosa*, n = 1. Regarding the resistance profile, 7 presented with a multiresistance profile (MDR) and extreme resistance (XDR). Univariate analysis identified the Model for End-Stage Liver Disease (MELD) pretransplant score as a factor associated with developing pneumonia ($P < .001$, 95% confidence interval [CI] 2.872–10.167), and early extubation, before 8 hours posttransplant, as a protective factor ($P = .008$; relative risk [RR] 0.124; 95% CI 0 .041–0.377). Hospital stay was longer in patients with pneumonia compared to those without pneumonia ($P < .0001$, 95% CI 17.79–43.11 days). There was also an increased risk of death in patients with pneumonia (RR 17.963; 95% CI 5106–63,195).

**Conclusions.** Early bacterial pneumonia after hepatic transplantation is associated with higher morbidity and mortality. At our center, 4 of 9 patients had bacteremia. GNB cases with MDR and XDR profiles are predominant. Early extubation is a protective factor.

POSTOPERATIVE pulmonary complications represent a major cause of morbidity and mortality and increased hospital stays in liver transplant patients [1]. These complications are classified as "infectious" (eg, pneumonia) or "noninfectious," as well as "early" (in the

*Address correspondence to Jimena Prieto Amorin, Programa de Trasplante Hepatico Hospital Militar, Postal 11500, Miami 2026, Montevideo, Uruguay. E-mail: jimeprieto78@gmail.com



0041-1345/18
https://doi.org/10.1016/j.transproceed.2017.11.047

**Table 1. Overview of the Population Having Received a Liver Transplant (n = 106)**

| Variables | |
|---|---|
| Median age (P25–P75) years | 45.91 (35–58) |
| Male, n (%) | 68 (64.2) |
| MELD pretransplantation, median (P25–P75) | 19.813 (15.75–22) |
| Illness that determined organ failure, n (%) | |
| Alcoholic cirrhosis | 26 (24.5) |
| Autoimmune | 17 (16.0) |
| Chronic hepatitis C | 12 (11.3) |
| Primary biliary | 7 (6.6) |
| More than 1 cause | 7 (6.6) |
| Others* | 37 (34.9) |
| Transplanted organ, n (%) | |
| Liver | 101 (95.3) |
| Liver/kidney | 5 (4.7) |
| Surgical information, mean (P25–P75) | 420 (364–505) |

Abbreviation: MELD, Model for End-Stage Liver Disease; P25, 25th percentile; P75, 75th percentile.

*Includes cryptogenic (6 patients), non-alcoholic steatohepatitis (4 patients), hepatitis B (5 patients), acute liver failure (4 patients), primary sclerosing cholangitis (4 patients), polycystic (3 patients), biliary atresia (2 patients), Wilson desease (2 patients), hemangioendothelioma (2 patients), hemochromatosis, deficit of $\alpha_1$-antitrypsin, portal cavernoma, secondary biliary cirrhosis, Budd–Chiari syndrome, and acute-on-chronic failure (1 patient each).

Data from the Bi-institutional Unit for Complex Liver Diseases (Hospital Militar, Hospital de Clinicas), Uruguay, July 14, 2009 to July 24, 2015.

first 100 days) or "late" (after 100 days). Globally, early complications (both infectious and noninfectious) have a high incidence (59%) and high morbidity and mortality rates, as described by Ulubay et al [2] and Pirat et al [3].

Posttransplant pneumonia in the first 100 days is a postoperative complication that results in greater morbidity and mortality, manifested as the need for prolonged use of mechanical ventilation, extended stay in the intensive care unit, and the need for a tracheotomy, among other complications [4–6]. Despite the use of antibiotic prophylaxis, improved surgical techniques, and optimization of immunosuppression, the incidence of pneumonia remains high, being the second-most frequent complication after intraabdominal surgery. Its incidence has been described to vary from 5% to 48% [6], depending on reporting institution.

Risk factors associated with posttransplant pneumonia in the first 100 days after liver transplantation include pretransplant conditions (intraoperative recipient age, restrictive respiratory pattern, Model for End-Stage Liver Disease [MELD] score, hemoglobin level, diabetes mellitus, and intraoperative factors [blood loss >10 L]) and posttransplantation circumstances (the need for surgical reintervention, retransplantation, and the duration of mechanical ventilation) [1–4,6]. Gram-negative bacilli (GNB) bacteria are the predominant microorganisms involved in posttransplant pneumonia, accounting for up to 84% [3–8].

The objectives of this study were to determine the incidence and morbidity/mortality associated with bacterial pneumonia in the first 100 days after liver transplantation at our center, as well as the microorganisms involved and the associated factors.

## METHODS

We performed a cohort study with data obtained from a national database BaDaInTOS. Patients who had undergone liver transplantation were included prospectively. All episodes of bacterial pneumonia occurring within the first 100 days posttransplant were included. The study period was from July 14, 2009 to July 24, 2015, and included patients in the Liver Transplant Program at the Bi-Institutional Unit of Complex Liver Diseases (Hospital Militar and Hospital de Clínicas) in Uruguay.

Liver transplant recipients (LTs) who had bacterial pneumonia within the first 100 days after transplantation were included in our study. Liver transplant recipients who died within the first 48 hours posttransplant were excluded.

A data collection form was designed for this work, the results of which were entered into an SPSS version 22 (IBM SPSS, Armonk, NY) database coded for the analysis.

The data collected for this work in the pretransplant period included: age; sex; transplanted organ; type of disease that determined organ failure; lymphocytosis; diabetes mellitus; MELD score; and immunosuppressive drugs. At the time of transplantation, we recorded whether the donor had an infectious process and whether surgical prophylaxis had been implemented in the recipient. Posttransplant data obtained included: time of extubation postsurgery; length of hospital stay; survival at discharge; early

**Table 2. Form of Presentation, Diagnosis, and Microorganism Isolated (n = 9)**

| Number Transplanted | Form of Presentation | Diagnosis | Bacteremia | MO Isolated | Day of Presentation |
|---|---|---|---|---|---|
| 15* | VAP | BAL | No | *Estreptococo beta hemolítico* | 1 |
| 18* | VAP | BAL | Yes | *Acinetobacter baumannii* | 1 |
| 23 | VAP | BAL | No | *Acinetobacter baumannii* | 5 |
| 27 | VAP | BAL | Yes | *Acinetobacter baumannii* | 72 |
| 33 | VAP/empyema | BAL + pleural fluid puncture | Yes | *Acinetobacter baumannii/Klebsiella* | 12 |
| 42 | VAP | BAL | No | *Enteroccocus faecium/Morganella morganii* | 9 |
| 52† | VAP | BAL | No | *Sin MO aislado* | 2 |
| 56 | HAP | Sputum | Yes | *Klebsiella* | 9 |
| 62 | HAP/empyema | Pleural fluid puncture | No | *Klebsiella/Pseudomonas aeruginosa* | 30 |

Abbreviations: BAL, bronchoalveolar lavage; HAP, hospital-acquired pneumonia; MO, microorganism; VAP, ventilator-associated pneumonia.

*Ventilated 24 hours before liver transplant.

†No isolated microorganism, but patient had compatible signs with VAP and favorable evolution under antibiotic treatment.

Data from the Bi-Institutional Unit for Complex Liver Diseases (Hospital Militar, Hospital de Clinicas), Uruguay, July 14, 2009 to July 24, 2015.

**Table 3. Isolated Microorganism and Its Susceptibility Profile in Bacterial Pneumonias (n = 11)**

| MO Antibiotic | AMK | GEN | AMS | AMP | CRO | CAZ | CIP | PTZ | TMP-SMX | Erta | MER | IMI | COL | VAN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Streptococcus beta hemolítico* | NT | NT | NT | S | NT | NT | NT | NT | NT | NT | NT | NT | NT | NT |
| *A baumanii* | NT | S | R | NT | R | R | R | NT | R | NT | R | R | S | NT |
| *A baumanii* | NT | S | R | NT | R | R | R | NT | R | NT | R | R | S | NT |
| *A baumanii* | NT | S | R | NT | R | R | R | NT | R | NT | R | R | S | NT |
| *A baumanii* | NT | S | R | NT | R | R | R | NT | R | NT | R | R | S | NT |
| *Klebsiella pneumoniae* | S | S | R | NT | R | R | R | NT | R | NT | S | S | NT | NT |
| *Enterococcus* spp | NT | NT | NT | S | NT | NT | NT | NT | NT | NT | NT | NT | NT | S |
| *Morganella morganii* | NT | NT | R | R | S | S | NT | NT | S | NT | S | S | NT | NT |
| *Klebsiella pneumoniae* | R | S | R | R | R | R | R | NT | S | S | S | S | NT | NT |
| *Klebsiella pneumoniae* | S | S | S | NT | S | S | S | NT | R | NI | S | S | NT | NT |
| *Pseudomonas aeruginosa* | R | R | NT | NT | NT | R | R | NT | NT | NT | R | R | S | NT |

Abbreviations: AMK, amikacin; AMP, ampicillin; CAZ, ceftazidime; CFX, cefuroxime; CIP, ciprofloxacin; COL, colistin; CRO, ceftriaxone; FEP, cefepime; GEN, gentamicin; GNB, Gram-negative bacilli; I, intermediate; IMP, imipenem; MEM, meropenem; MO, microorganism; NT, not tested; PTZ, piperacillin/tazobactam; R, resistant; S, susceptible; SAM, ampicillin/sulbactam; TMP-SMX, trimethoprim–sulfamethoxazole; VAN, vancomycin.
Data from the Bi-Institutional Unit for Complex Liver Diseases (Hospital Militar, Hospital de Clinicas), Uruguay, July 14, 2009 to July 24, 2015.

surgical reoperation; presence of pneumonia and type (nosocomial or associated with ventilation); and isolated microorganisms.

### Definitions

- Pneumonia: The definition of pneumonia was taken from the recommendations of Centers for Disease Control and Prevention (CDC) [9].
- Hospital-acquired pneumonia (HAP): An infection that affects the lung parenchyma and that manifests ≥48 hours after the patient's admission to the hospital, and not present at the time of intubation [9,10].
- Ventilator-associated pneumonia (VAP): Pneumonia development in patients undergoing mechanical ventilation [9,10].
- Multiresistant microorganism (MDR): A microorganism not susceptible to ≥1 agent in ≥3 antimicrobial categories [11].
- Extremely resistant microorganism (XDR): A microorganism not susceptible to ≥1 agent in all but ≤2 categories.
- Pan-resistant microorganism (PDR): A microorganism not susceptible to any antimicrobial agents [11].
- Model for End-Stage Liver Disease: Survival probability for a patient with end-stage liver disease based on the following objective variables: bilirubin; international normalized ratio; and creatinemia. The MELD score is a prognostic index that correlates with 3-month mortality.

### Ethics

All data are presented such that individual patients could not be identified.

### Statistical Analysis

Statistical calculations were performed using SPSS version 22.0. Numerical variables were expressed as mean and standard deviation. Chi-square tests were used to calculate statistical significance when the expected value of a box in the contingency tables was ≤5. Fisher's exact tests were used. $P < .05$ was considered significant. For comparison of means, Student's $t$ tests were used for independent samples.

### Outcomes

The study population consisted of a total of 106 transplanted patients. Of these, 68 (64%) were male with a median age 49 years (Table 1), and a mean hospital stay (P25–P75) of 19 (9–22) days. Ninety-five (92.5%) patients were alive at discharge. The cumulative incidence of precocious bacterial pneumonia was 8.5% (9 of 106 patients). Of these, 7 patients presented with VAP and 2 with HAP. Of the 9 cases, 4 presented with bacteremia and 2 with empyema. The microbiologic diagnostic method was broncheoalveolar lavage (BAL) in 6 cases, BAL and pleural fluid puncture in 1, pleural fluid puncture in 1, and a sputum study in 1 (Table 2).

Bacterial pneumonia presented at an average of 9 (P25: 2; P75: 26) days. Mean hospitalization time in patients with pneumonia was 47 days, compared with 16.9 days for those who did not present with this complication (95% confidence interval [CI] 17.79–43.11 days).

Regarding survival at discharge, among patients with pneumonia (n = 9), 5 died before discharge. In the group that did not present with pneumonia (n = 97), 3 patients died before discharge ($P < .0001$; relative risk [RR] 17.963; 95% CI 5106–63,195).

Eleven microorganisms were isolated in 9 patients (1 patient without microbiologic isolation, 3 with >1 microorganism, and the rest with 1 isolation each) (Table 2). Of the 11 microorganisms, 9 corresponded to Gram-negative bacilli (GNB): *Klebsiella* spp, n = 3; *Acinetobacter baumannii*, n = 4; *Morganella morganii*, n = 1; and *Pseudomonas aeruginosa*, n = 1. There were 2 positive cocaceae: β-hemolytic *Streptococcus* of group b (n = 1) and *Enterococcus faecium* (n = 1).

In 1 case, no microorganism was isolated. Regarding the sensitivity profile of the GNBs, 7 presented with MDR and XDR patterns. No multiresistant-positive cocaceae were isolated (Table 3).

Pretransplant MELD score was higher in patients who had pneumonia than in those who did not (19 and 25, respectively; 95% CI 2,872–10,167). Early extubation (before 8 hours posttransplantation) was shown to be a protective factor for pneumonia ($P = .008$; RR 0.124; 95% CI 0.041–0.377) (Table 4).

## DISCUSSION

Our work represents the first national report of early bacterial pneumonia (first 100 days posttransplant) in hepatic transplant recipients. An incidence of 8.5% (2 HAP cases and 7 cases with VAP) was documented. Although the incidence at our center is relatively low (reported

**Table 4. Potential Associated Factors for Bacterial Pneumonia**

| Variable | Pneumonia (n = 9) | Pneumonia NO (n = 97) | *P* | RR | 95% CI |
|---|---|---|---|---|---|
| Pretransplant | | | | | |
| MELD | 9 | 97 | .0001 | | 2872–10,167 |
| Diabetes mellitus | | | | | |
| Yes | 0 | 16 | .349 | 1.111 | 1.037–1.190 |
| No | 9 | 81 | | | |
| Immunosuppressive drugs | | | | | |
| Yes | 2 | 17 | .662 | 1.308 | 0.295–5.811 |
| No | 7 | 80 | | | |
| Lymphopenia (<1000) | | | | | |
| Yes | 5 | 44 | .730 | 1.454 | 0.413–5.117 |
| No | 4 | 53 | | | |
| Age (mean 49 years) > 49 | | | | | |
| Yes | 5 | 49 | 1 | 1.181 | 0.336–4.153 |
| No | 4 | 47 | | | |
| Donor infection | | | | | |
| Yes | 4 | 24 | .24 | 2.229 | 0.644–7.715 |
| No | 5 | 74 | | | |
| Posttransplant | | | | | |
| Reintervention | | | | | |
| Yes | 3 | 11 | .096 | 3.286 | 0.926–11.662 |
| No | 6 | 86 | | | |
| Extubation, before 8 hours* | | | | | |
| Yes | 6 | 91 | .008 | 0.124 | 0.041–0.377 |
| No | 3 | 3 | | | |

Abbreviations: CI, confidence interval; MELD, Model for End-Stage Liver Disease.
*The date and time of extubation is not included for 3 of the patients.
Data from univariate analysis of the Bi-Institutional Unit for Complex Liver Diseases (Hospital Militar, Hospital de Clinicas), Uruguay, July 14, 2009 to July 24, 2015.

international values range from 5% to 48%) [6], almost half of the episodes (4 of 9) were accompanied by bacteremia and in 2 cases by empyema. The incidence of bacteremia in patients with pneumonia was higher in our study than the 22% (9 of 41 patients) found by Singh et al [12].

The diagnosis of VAP in the first 24 hours after hepatic transplantation in 2 patients was secondary to the fact that these patients arrived at the transplant center with severe disease and needed preoperative ventilation for >24 hours. Therefore, they were considered VAP, as they had been ventilated for >48 hours at the time of pneumonia diagnosis.

Early postoperative pneumonia in LT patients represents a major cause of morbidity and mortality, as reported by Levesque et al [1]. At our center, we found that, among patients who presented with pneumonia compared with those who did not, there was a lower percentage of living patients at hospital discharge. A similar phenomenon was seen for hospital stay; patients who presented with pneumonia had longer stays compared to those without: mean 47 days vs 16.9 days, respectively ($P < .0001$; 95% CI 17.79–43.11 days).

A microbiologic diagnosis was made in a high percentage of cases (8 of 9), which benefitted the patients, who were then able to implement treatments directed toward the identified microorganisms.

The diagnosis of pneumonia was microbiologically confirmed because all invasive studies were conducted to identify the responsible microorganism (including BAL and pleural puncture, when indicated) (Table 2). Eleven microorganisms were isolated (1 patient without microbiologic isolation, 3 with >1 microorganism, and the rest with 1 isolation each). The tendency for >1 organism to be identified in patients with VAP was already reported by Ruiz et al, where polymicrobial pneumonia was second in frequency [13].

One patient who was not targeted for microbiologic isolation was interpreted as having pneumonia as the symptoms fulfilled the clinical criteria. This patient's condition improved dramatically with antibiotic treatment.

Analysis of these microbiologic findings shows a clear predominance of GNB (9 of 11 isolates). This predominance is concordant with findings reported elsewhere [14,15]. For instance, in 2012, Ikegami et al reported a predominance of GNB, seen in up to 84% of the bacterial pneumonia cases in LT recipients [16].

Regarding the sensitivity profile of GNB, 7 of 10 were MDR and XDR. This high percentage of patients with multidrug resistance is an established problem both in Uruguay and worldwide, as reported by Cervera et al [17]. In our study, *Acinetobacter baumannii* presented a profile of XDR in 4 of 4 isolates, which is consistent with the results reported by our group for surgical site infection in 2014 [18] and 2016 [19], as well as with those from another reno-pancreas transplant center in Uruguay in 2012 [20].

The findings have certain implications for the prognosis of patients. In a 2011 retrospective study of 451 liver

transplants, Kim et al showed that secondary infections with XDR *Acinetobacter baumannii* were an independent predictor of mortality, mainly due to inappropriate use of empirical antimicrobial therapy to cover this organism [21]. Bacteremic episodes with these microorganisms determined increased morbidity and mortality in these patients. Of the 4 cases of bacteremia at our center, 3 were secondary to *A baumannii* XDR, and 1 was secondary to *Klebsiella pneumoniae.* These data coincide with findings by Spanga et al, who found that most bacteremia were secondary to nonfermenting GNB and enterobacteria with MDR and XDR profiles, generating high morbidity and mortality [22].

Univariate analysis identified pretransplant MELD score as a factor associated with developing pneumonia (95% CI 2872–10,167) and early extubation, before 8 hours posttransplant, as a protective factor ($P = .008$; RR 0.124; 95% CI 95% 0.041–0.377). The value of MELD score at retransplantation has already been widely demonstrated in other reports as an associated factor for posttransplant pneumonia, as shown by Aydin et al in 2015, who found that MELD score >16 was associated with presenting complications after pulmonary transplantation, and death [5]. Our study has shown that, globally, our patients presented with a high MELD score (mean 19), but the patients with pneumonia presented with a significantly higher value than those who did not present this complication, with MELD scores of 25 and 19, respectively ($P < .001$; 95% CI 2872–10,167).

Alteration in liver function in the pretransplant stage is a predictive factor of infectious complications posttransplant, particularly bacterial pneumonia. Early extubation, before 8 hours, proved to be a significant protective factor against posttransplant pneumonia ($P = .008$; RR 0.124; 95% CI 0.041–0.377). These results, which are in line with those described elsewhere [23,24], are mainly due to the disruption of mucosal barriers, which are altered by mechanical ventilation. As the work published by Aydin et al, along with several other reports, has already shown [5], prolonged ventilation, with a cutoff point of >3 days, is a factor clearly associated with early postoperative lung complications.

Although one of the main limitations of our work is the small number of patients, our results are in line with those reported from other centers. This will allow us to delineate empirical plans regarding microbiology at our center, given that starting suitable antimicrobial treatment is fundamental in treatment of these patients.

## CONCLUSIONS

Early bacterial pneumonia after hepatic transplantation is associated with increased morbidity and mortality. At our center, patients were bacteremic in 4 of 9 cases. GNB cases with MDR and XDR profiles prevailed. Early extubation is a protective factor.

## REFERENCES

[1] Levesque E, Hoti E, Honore I, et al. Pulmonary complications after elective liver transplantation—incidence, risk factors, and outcome. Transplantation 2012;94:532–8.

[2] Ulubay G, Dedekarginoglu B, Kupeli E, et al. Postoperative pulmonary complications in living-liver donors: a retrospective analysis of 188 patients. Exp Clin Transplant 2015;13(suppl 1): 340–5.

[3] Pirat A, Ozgur S, Torgay A, et al. Risk factors for postoperative respiratory complications in adult liver transplant recipients. Transplant Proc 2004;36:218–20.

[4] Feltracco P, Carollo C, Barbieri S, et al. Post-liver transplant pulmonary complications. World J Gastroenterol 2013;19: 9271–81.

[5] Aydin E, Otan E, Akbulut S, et al. Postoperative pulmonary complications after liver transplantation: assessment of risk factors for mortality. Transplant Proc 2015;47:1488–94.

[6] Xia D, Yan LN, Xu L, et al. Postoperative severe pneumonia in adult liver transplant recipients. Transplant Proc 2006;38:2974–8.

[7] De Gasperi A, Feltracco P, Ceravola F, Mazza F. Pulmonary complications in patients receiving a solid-organ transplant. Curr Opin Crit Care 2014;20:411–9.

[8] Weiss E, Dahmani S, Bert F, et al. Early-onset pneumonia after liver transplantation: microbiological findings and therapeuticconsequences. Liver Transpl 2010;16:1178–85.

[9] Centers for Disease Control and Prevention. Pneumonia (ventilator-associated [VAP] and non-ventilator-associated pneumonia [PNEU]). 2014. http://www.cdc.gov/nhsn/pdfs/pscmanual/6pscvapcurrent.pdf/. Accessed June 2016.

[10] Estudio nacional de Vigilancia de Infección Nosocomial en Servicios de Medicina Intensiva (ENVIN- HELICS). http://hws.vhebron.net/envin-helics/Help/Manual.pdf/. [Accessed 2 December 2014].

[11] Magiorakos A, Srinivasan A, Carey RB, et al. Multidrug-resistant, extensively drug-resistant and pandrug-resistant bacteria: an international expert proposal for interim standard definitions for acquired resistance. Clin Microbiol Infect 2012;18:268–81.

[12] Singh N, Paterson DL, Gayowski T, et al. Predicting bacteremia and bacteremic mortality in liver transplant recipients. Liver Transpl 2000;6:54–61.

[13] Ruiz M, Guerrero J, Romero C. Etiology of ventilator-associated pneumonia in a university hospital. Association with comorbidity, previous use of antibiotics and mortality. Rev Chil Infect 2007;24:131–6.

[14] Cervera C, Agustí C, Angeles Marcos M, et al. Microbiologic features and outcome of pneumonia in transplanted patients. Diagn Microbiol Infect Dis 2006;55:47.

[15] Bonatti H, Pruett TL, Brandacher G, et al. Pneumonia in solid organ recipients: spectrum of pathogens in 217 episodes. Transplant Proc 2009;41:371–4.

[16] Ikegami T, Shirabe K, Matono R, et al. Etiologies, risk factors, and outcomes of bacterial pneumonia after living donor liver transplantation. Liver Transpl 2012;18:1060–1068.

[17] Cervera C, van Delden C, Gavaldà J, et al. Multidrug-resistant bacteria in solid organ transplant recipients. Clin Microbiol Infect 2014;20:49–73.

[18] Prieto J, Medina JC, Lopez M, et al. Infección de sitio quirúrgico en el Programa de Trasplante Hepático en Uruguay: alta incidencia de bacilos gramnegativos multirresistentes y extremadamente resistentes. Rev Méd Urug 2014;30:112–22 [in Spanish].

[19] Prieto J, Medina JC, Lopez M, et al. Impact of a multimodal approach in prevention of surgical site infection in hepatic transplant recipients. Transplant Proc 2016;48:658–64.

[20] Medina JC, Antelo V, Nin M, et al. Infecciones bacterianas en pacientes receptores de trasplante renal y reno-páncreas: alta incidencia de microorganismos multirresistentes. Rev Méd Urug 2012;28:190–8 [in Spanish].

[21] Kim YJ, Yoon JH, Kim SI, et al. High mortality associated with *Acinetobacter* species infection in liver transplant patients. Transplant Proc 2011;43:2397–9.

[22] Spanga G, Spanu T, Bianco G, et al. Bacterial bloodstream infections in liver transplantation: etiologic agents and antimicrobial susceptibility profiles. Transplant Proc 2012;44:1973–6.

[23] Siniscalchi A, Aurini A, Benini B, et al. Ventilator associated pneumonia following liver transplantation: etiology, risk factors and outcome. World J Transplant 2016;24:389–95.

[24] Wu J, Rastogi V, Zhenq SS. Clinical practice of early extubation after liver transplantation. Hepatobil Pancreat 2012;15(11):577–85.