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Original Article

Clinical and bacteriological characteristics of pyogenic liver abscess in non-diabetic patients

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Background and purpose: Diabetes mellitus is an important risk factor for *Klebsiella pneumoniae* liver abscess, but many patients with pyogenic liver abscess (PLA) do not have diabetes. This study was conducted to compare the clinical characteristics and prognostic factors of *K. pneumoniae* PLA with that caused by other organisms in non-diabetic patients.

Methods: The medical charts of patients with a diagnosis of PLA were retrospectively reviewed from January 2005 to December 2007. The clinical symptoms and signs, laboratory data, and risk factors were analyzed.

Results: There were 50 patients in the *K. pneumoniae* group and 34 patients in the non–*K. pneumoniae* group. The clinical presentations did not differ between the 2 groups. The patients in the non–*K. pneumoniae* group had a higher prevalence of malignant disease than those in the *K. pneumoniae* group (58.8% vs 6.0%; $p < 0.001$). Non–*K. pneumoniae* PLA was strongly associated with hepatobiliary tumor ($p = 0.015$). Among the non–*K. pneumoniae* isolates, *Escherichia coli* was the most common pathogen (n = 20; 58.8%). Forty seven *K. pneumoniae* isolates (94%) were susceptible to all tested antimicrobial agents except ampicillin, while the non–*K. pneumoniae* Gram-negative pathogens had greater resistance to first-generation cephalosporins. Poor prognostic factors included chronic renal failure ($p = 0.005$), abscess rupture ($p = 0.036$), and right lower lung infiltration ($p = 0.049$).

Conclusions: Hepatobiliary malignancy and newly diagnosed malignancy were risk factors for non–*K. pneumoniae* liver abscess in non-diabetic patients. Physicians should ascertain the presence of underlying malignancy in patients with non–*K. pneumoniae* PLA.

Key words: Diabetes mellitus; *Klebsiella pneumoniae*; Liver abscess, pyogenic

Introduction

Pyogenic liver abscess (PLA) is a common intra-abdominal infection in Taiwan. It is usually caused by *Klebsiella pneumoniae*, which has caused 52% to 78% of PLA in the past 2 decades [1,2]. However, a variety of microorganisms are considered to be potential pathogens, especially in patients with PLA of biliary origin and coexisting malignancy [3-5]. Although diabetes mellitus has been increasingly recognized as an important risk factor for *K. pneumoniae* liver abscess [3,6,7], more than half of the patients with PLA do not have diabetes, both in western and Asian countries [1,8-10]. The pathogenesis remains unclear, but it is relevant to find the risk factors for PLA, especially for patients without diabetes. Many investigators have mentioned the importance of the etiology of liver abscess for providing effective treatment, and some degree of risk for malignancy should be considered other than hepatobiliary and pancreatic diseases [11-13]. Moreover, few studies of PLA have focused on patients without diabetes.

All of the community-acquired *K. pneumoniae* liver abscess isolates in a previous study were susceptible to all tested antimicrobial agents except for ampicillin [7]. However, the susceptibility of other

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pathogens (non–*K. pneumoniae*) varied [4,14]. The difference in antimicrobial susceptibility between *K. pneumoniae* and non–*K. pneumoniae* groups might affect the effectiveness of treatment and the outcome.

This study aimed to compare PLAs caused by *K. pneumoniae* and non–*K. pneumoniae* in non-diabetic patients, and to identify factors associated with distal metastasis and case mortality.

Methods

Patients

Adult patients (age, 18 years or older) without diabetes who were diagnosed with PLA at a medical center in North Taiwan from January 2005 to December 2007 were included. Data were obtained by retrospective review of the medical records. Patients were considered to be free from diabetes mellitus if the following criteria were met: fasting blood glucose <126 mg/dL, random blood glucose <200 mg/dL [15] or hemoglobin A_{1C} (HbA_{1C}) <6.2%. Patients were included if the abscess was confirmed by imaging study as well as isolation of an organism either from the abscess or blood. Amebic liver abscess was excluded. Patients were allocated to the *K. pneumoniae* group if *K. pneumoniae* was isolated, even in the presence of polymicrobial infection. Patients without *K. pneumoniae* were allocated to the non–*K. pneumoniae* group.

Definitions

Biliary tract diseases included gallbladder stone, intrahepatic duct stone, common bile duct stone, pneumobilia, fistula, or intrahepatic duct/common bile duct dilatation, cholangitis, and cholecystitis. Empirical antimicrobial agents were defined as the antimicrobial agents prescribed before the culture results became available and that had been given for at least 3 days. Appropriate antibiotic therapy was defined as an empirical antibiotic to which the PLA pathogen was susceptible. Complications were defined as occurrence of septic encephalopathy, acute respiratory failure, acute renal failure, septic shock, thrombocytopenia, abscess rupture, and distal metastases. Clinically, septic encephalopathy was defined as changes in behavior, cognition, awareness, and consciousness [16]. Computed tomography (CT) of the brain was performed to rule out brain abscess, if required. Acute respiratory failure was defined as the oxygenation index PaO_2/FiO_2 (arterial oxygen tension divided by inspired oxygen fraction) <200 or endotracheal intubation. Acute renal failure was defined as an abrupt absolute increase in serum creatinine level of ≥0.3 mg/dL from baseline within 48 h or a ≥50% increase in serum creatinine, or oliguria with urine output <0.5 mL/kg per h for more than 6 h [17]. Distal metastasis suggested the presence of infectious foci other than the liver with or without culture reports from the metastatic sites. Endogenous endophthalmitis was clinically diagnosed by an ophthalmologist with or without positive aqueous or vitreous culture.

Microbiology and antimicrobial susceptibility testing

Blood culture samples were processed by the BACTEC NR-660 system (Becton Dickinson, Spark, MD, USA). An automatic identification system for Gram-negative rods (ID 32 GN; bioMérieux Vitek, Marcy l'Etoile, France) was used for species identification. Susceptibility to antimicrobial agents was determined by using the Bauer-Kirby disk-diffusion method on Mueller-Hinton agar medium, as recommended by the guidelines of the Clinical and Laboratory Standards Institute [18].

Statistical analysis

All collected data were transcribed into Microsoft Access 2003 and analyzed using the Statistical Package for the Social Sciences (SPSS) for Windows (Version 15; SPSS, Inc., Chicago, IL, USA). Univariate analysis was performed by Student's *t* test and Mann-Whitney *U* test for continuous variables, depending on whether the data had a normal distribution, chi-squared test for categorical variables, and Fisher's exact test for every table with any expected value <5. Multivariate logistic regression analysis was performed to analyze the independently significant variables from the univariate analyses to identify the factors associated with non–*K. pneumoniae* infection or with distal metastasis and mortality. A p value of <0.05 was considered statistically significant for all analyses. Odds ratios (OR) and 95% confidence intervals (CI) were estimated in the logistic regression models.

Results

Patients' characteristics

Between January 2005 and December 2007, 348 patients were diagnosed with PLA. 138 patients with PLA (39.7%) had diabetes mellitus, and 210 (60.3%) were non-diabetic. Among the non-diabetic patients, 157 (74.8%) had microbiologic reports, and *K. pneumoniae*

was the predominant pathogen (n = 99; 63.1%). There were 84 patients with PLA with complete medical records and culture-positive results that met the inclusion criteria. Among them, 50 and 34 patients were identified in the *K. pneumoniae* and non–*K. pneumoniae* groups, respectively.

Patients in the *K. pneumoniae* group were younger than those in the non–*K. pneumoniae* group, but this difference was not significant (mean ± standard deviation [SD], 59.92 ± 19.36 years vs 66.71 ± 17.52 years; $p = 0.073$). The male-to-female ratio was comparable in both groups at 1.5 and 1.4, respectively. The underlying diseases associated with PLA are listed in Table 1. The most common underlying disease in the *K. pneumoniae* group was benign biliary tract disease (n = 16; 32%), and 17 patients (34%) had no underlying disease. In the non–*K. pneumoniae* group, the most common underlying disease was malignancy (n = 20; 58%), followed by benign biliary tract disease (n = 17; 50%).

The prevalence of malignancy among the non–*K. pneumoniae* group was higher than in the *K. pneumoniae* group (58.8% vs 6.0%; $p < 0.001$), especially gastrointestinal tract tumors, including hepatocellular carcinoma (n = 5), gallbladder adenocarcinoma (n = 2), cholangiocarcinoma (n = 2), Klatskin tumor (n = 2), ampulla vater adenocarcinoma (n = 1), gastric cancer (n = 4), and sigmoid adenocarcinoma (n = 1). Of the patients with PLA and malignancy, 6 had procedure-related PLA — 1 from the *K. pneumoniae* group and 5 from the non–*K. pneumoniae* group. Other significant risk factors were gastrointestinal tract operations within 2 months (2.0% in the *K. pneumoniae* group vs 20.6% in the non–*K. pneumoniae* group; $p < 0.01$) and hepatitis C carrier status (0% in the *K. pneumoniae* group vs 23.5% in the non–*K. pneumoniae* group; $p < 0.05$).

There was no difference in clinical symptoms and signs for *K. pneumoniae* and non–*K. pneumoniae* liver abscesses (Table 2). However, patients in the non–*K. pneumoniae* group had lower hemoglobin (mean ± SD, 11.04 ± 2.39 g/dL vs 12.62 ± 2.00 g/dL; $p < 0.01$), C-reactive protein (mean ± SD, 12.40 ± 8.72 vs 17.79 ± 7.86 mg/dL; $p < 0.01$), and serum creatinine levels (mean ± SD, 1.29 ± 0.57 vs 1.61 ± 1.06 mg/dL; $p < 0.05$). Blood culture was positive for 21 patients (42.0%) in the *K. pneumoniae* group and 16 (47.1%) in the non–*K. pneumoniae* group (Table 2). Patients in the non–*K. pneumoniae* group had more incidence of polymicrobial infection than did those in the *K. pneumoniae* group (38.2% vs 4.0%; $p < 0.001$).

Abdominal CT demonstrated that an internal septum within the abscess was more often encountered in the *K. pneumoniae* group (Table 3). Other radiological

Table 1. Clinical characteristics of non-diabetic patients with pyogenic liver abscess caused by *Klebsiella pneumoniae* and non–*K. pneumoniae*.

Variable	*K. pneumoniae* (n = 50) No. (%)	Non–*K. pneumoniae* (n = 34) No. (%)	*p*
Sex			
Male	30 (60.0)	20 (58.8)	0.914
Female	20 (40)	14 (41.2)	
Age (years; mean ± SD)	59.92 ± 19.36	66.71 ± 17.52	0.073
Underlying conditions			
Malignancy	3 (6.0)	20 (58.8)	<0.001
Hepatobiliary tract tumor	1 (2.0)	13 (38.2)	<0.001
Chemotherapy or corticosteroid treatment	0 (0)	3	0.063
Cerebrovascular accident	5 (10.0)	0 (0)	0.078
Collagen vascular disease	0 (0)	1 (2.9)	0.405
Biliary tract diseases[a]	16 (32.0)	17 (50.0)	0.097
Liver cirrhosis	1 (2.0)	4 (11.8)	0.153
Gastrointestinal surgery within 2 months	1 (2.0)	7 (20.6)	<0.05
Chronic obstructive pulmonary disease	1 (2.0)	2 (5.9)	0.563
Chronic renal insufficiency	3 (6.0)	2 (5.9)	1
Hepatitis B antigen–positive[b]	5 (20.8)	6 (33.3)	0.483
Anti-hepatitis C antibody–positive[c]	0 (0)	4 (23.5)	<0.05
No underlying disease	17 (34.0)	4 (11.8)	<0.05

[a]Including biliary tract abnormality or infection.

[b]Data available for 42 patients.

[c]Data available for 44 patients.

Table 2. Clinical characteristics and laboratory findings of pyogenic liver abscess in non-diabetic patients.

Characteristic	*Klebsiella pneumoniae* (n = 50) No. (%)	Non–*K. pneumoniae* (n = 34) No. (%)	*p*
Signs and symptoms			
Fever	43 (86.0)	28 (82.4)	0.65
Chills	33 (66.0)	21 (61.8)	0.691
Diarrhea	10 (20.0)	6 (17.6)	0.787
Nausea/vomiting	18 (36.0)	9 (26.5)	0.359
Anorexia	14 (28.0)	9 (26.5)	0.877
Right upper quadrant pain/tenderness	26 (52.0)	16 (47.1)	0.657
Respiratory symptoms[a]	18 (36.0)	13 (38.2)	0.835
Hepatomegaly	2 (4.0)	0 (0)	0.512
Laboratory findings[b]			
White blood cells (/μL; mean ± SD)	15,392 ± 10,480	14,762 ± 9536	0.452
Hemoglobin (g/dL; mean ± SD)	12.62 ± 2.00	11.04 ± 2.39	<0.05
Alanine aminotransferase (U/L; mean ± SD)	87.81 ± 117.18	75.81 ± 132.25	0.111
Aspartate aminotransferase (U/L; mean ± SD)	113.66 ± 167.09	105.42 ± 169.36	0.303
Alkaline phosphatase (U/L; mean ± SD)	170.45 ± 129.05	206.43 ± 187.80	0.572
Total bilirubin (mg/dL; mean ± SD)	1.63 ± 1.08	1.82 ± 2.41	0.136
Albumin (g/dL; mean ± SD)	3.22 ± 0.60	2.97 ± 0.68	0.17
C-reactive protein (mg/dL; mean ± SD)	17.79 ± 7.86	12.40 ± 8.72	<0.05
Creatinine[c] (mg/dL; mean ± SD)	1.61 ± 1.06	1.29 ± 0.57	<0.05
Microbiology findings			
Blood culture positive	21 (42.0)	16 (47.1)	0.647
Liver aspirate culture			
Monomicrobial	48 (96.0)	21 (61.8)	<0.001
Polymicrobial	2 (4.0)	13 (38.2)	<0.001

[a]Including cough or dyspnea.

[b]The laboratory tests were done within 24 h except for albumin, which was done within 1 week.

[c]Excluding patients with chronic renal insufficiency.

Table 3. Results for imaging studies of pyogenic liver abscess in non-diabetic patients.

Characteristic	*Klebsiella pneumoniae* (n = 50) No. (%)	Non–*K. pneumoniae* (n = 34) No. (%)	*p*
Location			
Right lobe	34 (73.9)	23 (74.2)	0.978
Both lobes	3 (6.5)	3 (9.7)	0.68
Multiple abscesses	12 (26.1)	10 (32.3)	0.557
Ultrasound findings			
Hypoechogenity	23 (65.7)	10 (52.6)	0.346
Mixed echogenity	9 (25.7)	8 (42.1)	0.216
Abdominal computed tomography findings			
Internal septum	10 (24.4)	0 (0)	<0.05
Gas in abscess	2 (4.9)	5 (16.1)	0.132
Biliary tract abnormality	16 (36.4)	10 (32.3)	0.713
Chest radiograph findings			
Right lower lung infiltration	4 (8.3)	7 (21.9)	0.105
Right pleural effusion	4 (8.3)	6 (18.8)	0.187
Diaphragm elevation	7 (14.6)	5 (15.6)	1
Air-fluid level below right diaphragm	2 (4.2)	2 (6.3)	1

findings, such as air-fluid level below the right diaphragm, had a similar incidence between the 2 groups.

Overall, multivariate analysis showed that the presence of hepatobiliary tumor (OR, 0.051; 95% CI, 0.005-0.558; $p = 0.015$) was the independent risk

factor most associated with non–*K. pneumoniae* liver abscess.

Microbiology and antimicrobial susceptibility testing

Results of antimicrobial susceptibility testing of the bacterial isolates were available for 46 of 50 patients in the *K. pneumoniae* group. Forty three *K. pneumoniae* isolates (93.5%) were susceptible to all tested antimicrobial agents except for ampicillin. In addition to ampicillin, the antimicrobials that the other 3 isolates were resistant to included trimethoprim-sulfamethoxazole, chloramphenicol, gentamicin, ciprofloxacin, tetracycline, and piperacillin-tazobactam. These 3 isolates were susceptible to all generations of cephalosporins.

Fifty non–*K. pneumoniae* isolates from blood or liver aspirates were recovered from 34 patients in the non–*K. pneumoniae* group. *Escherichia coli* was the most common pathogen (n = 20; 58.8%), followed by *Serratia marcescens* (n = 5; 14.7%). Five *E. coli* liver abscesses (25%) were polymicrobial. Isolation of *Bacteroides fragilis* was relatively low (n = 4; 11.8%), and 50% of the cultures grew concomitantly with other pathogens of *Proteus vulgaris*, *Enterococcus* spp. or *Clostridium perfringens*. Overall, the polymicrobial infection rate in the non–*K. pneumoniae* group was 38.2% (n = 13) and was found predominantly in the patients with malignancy (n = 10; 76.9%).

Table 4 shows the pathogens isolated from blood or liver aspirates in the non-diabetic patients with PLA with malignancy. In the non–*K. pneumoniae* group, 20 patients had underlying malignancy. Monomicrobial culture was found in 10 patients (50%). The most common pathogen was *E. coli* (n = 8), followed by *Enterobacter cloacae* (n = 1), and *B. fragilis* (n = 1). Polymicrobial cultures were found in the other 10 patients. The most common pattern of mixed infection was *E. coli* plus other enteric species, which accounted for 40% of the polymicrobial infections.

The Gram-negative microorganisms in the non–*K. pneumoniae* group had high resistance rates to multiple antimicrobial agents. *E. coli* isolates were resistant to ampicillin (66.7%), cefazolin (18.2%), and gentamicin (23.8%).

Table 4. Pathogens isolated from blood or liver aspirate from non-diabetic patients with malignancy.

Pathogen/malignancy	No. of patients
Klebsiella pneumoniae group	3
K. pneumoniae only	2
Hepatocellular carcinoma	1
Non-papillary carcinoma of ureter	1
K. pneumoniae + *Escherichia coli*	1
Colon cancer	1
Non–*K. pneumoniae* group	20
Monomicrobial	10
E. coli	8
Hepatocellular carcinoma	1
Gallbladder adenocarcinoma	2
Cholangiocarcinoma[a]	1
Gastric cancer	3
Prostate cancer[a]	1
Enterobacter cloacae	1
Klatskin tumor	1
Bacteroides fragilis	1
Sigmoid cancer	1
Polymicrobial	10
E. coli + *Citrobacter freundii*	1
Hepatocellular carcinoma	1
E. coli + *Morganella morganii*	
Cholangiocarcinoma	1
E. coli + *Proteus mirabilis*	
Ampulla vater adenocarcinoma	1
E. coli + *Enterococcus* spp.	
Acute myeloid leukemia	1
Enterococcus + *Proteus vulgaris* + *B. fragilis*	
Hepatocellular carcinoma	1
Streptococcus spp. + *Prevotella* spp.	
Hepatocellular carcinoma	1
Serratia marcescens + *Alcaligenes xylosoxidans*	1
Klatskin tumor	1
Acinetobacter spp. + *Aerococcus* spp.	1
Neurogenic tumor	1
Candida glabrata + Gram-positive bacillus	1
Gastric cancer	1
Miscellaneous[a]	1
Hepatocellular carcinoma	1

[a]Liver aspirate culture with more than 3 different microorganisms.

Treatment and outcomes

The mean ± SD duration of antimicrobial therapy was 42.2 ± 27.2 days and 45.7 ± 54.1 days in the *K. pneumoniae* and non–*K. pneumoniae* groups, respectively, and included oral antimicrobial courses of 20.9 ± 24.1 days and 19.4 ± 20.9 days, respectively. Empirical antimicrobial therapy with third-generation cephalosporins was given to 30.0% and 35.3% of patients in the *K. pneumoniae* and non–*K. pneumoniae* groups, respectively. Overall, the appropriateness of empirical therapy was 100% and 61.76%, respectively.

The management of liver abscesses comprised aspiration, pigtail catheter drainage, and/or surgical

drainage if the size of the liver abscess was ≥3 cm by abdominal ultrasound or CT.

Empirical therapy with a third-generation cephalosporin was given to the 2 groups indiscriminately, and the mortality rates were similar. Among the 4 patients who died of liver abscess, 3 had received third-generation cephalosporins. Even though inappropriate empirical antibiotics had been given to 38.2% of patients in the non–*K. pneumoniae* group, none experienced metastatic complications or mortality. All but 1 patient had undergone aspiration drainage and/or pigtail drainage.

Only 2 patients in the *K. pneumoniae* group experienced a recurrence, while 3 episodes of recurrence occurred in 2 patients in the non–*K. pneumoniae* group. All the patients had biliary tract abnormality or hepatobiliary tumor. Two of 4 patients had gallbladder stones and the other 2 had hepatobiliary tumors, including Klatskin tumor with liver metastasis and hepatocellular carcinoma, for which the patient underwent transarterial embolization.

Complications occurred at similar rates in the *K. pneumoniae* and non–*K. pneumoniae* groups, including septic encephalopathy (4.0% vs 11.8%; $p = 0.216$), acute respiratory failure (6.0% vs 14.7%; $p = 0.26$), acute renal failure (34.0% vs 32.4%; $p = 0.875$), septic shock (16.0% vs 29.4%; $p = 0.141$), abscess rupture (12.0% vs 8.8%; $p = 0.733$), and distal metastasis (4.0% vs 2.9%; $p = 1$). Metastasis occurred in 2 patients with endophthalmitis and 1 patient with splenic abscess in the *K. pneumoniae* and non–*K. pneumoniae* groups, respectively. The 3 patients recovered well after treatment and all survived. The overall mortality rates were 8.0% (n = 4) and 5.9% (n = 2) in the *K. pneumoniae* and non–*K. pneumoniae* groups, respectively, with attributable mortality of 4.0% (n = 2) and 5.9% (n = 2), respectively. Most of the patients who died due to the liver abscess died within 1 week of the abscess occurring (mean, 4.5 days; range, 1-8 days).

Multivariate analysis of the prognostic factors of distal metastasis and mortality investigated chronic renal insufficiency, acute renal failure, septic shock, abscess rupture, and right lower lung infiltration on chest radiograph. Three factors were independently associated with distal metastasis and case mortality, including chronic renal failure (OR, 102.3; 95% CI 4.1-2560.2; $p = 0.005$), abscess rupture (OR, 16.3; 95% CI, 1.2-220.6; $p = 0.036$), and right lower lung infiltration (OR, 13.6; 95% CI 1.0-182.2; $p = 0.049$).

Discussion

This study demonstrated that malignancy, especially hepatobiliary tumors, was highly associated with non–*K. pneumoniae* pathogens in PLA among non-diabetic patients. Although a high incidence of malignancy in the non–*K. pneumoniae* group was found in previous studies, ranging from 19.5% to 30.6% [4,6,19], this study found a higher prevalence of malignancy (58.8%), suggesting an increasing tendency for malignancy in patients with non–*K. pneumoniae* PLA. The mechanism remains unclear, but may be due to a change in immune status or colonization of pathogens after invasive procedures such as transarterial embolization or percutaneous ethanol injection therapy [20-22]. Another reason might be the increasing incidence of *K. pneumoniae* as the etiology of PLA in patients with benign biliary tract disease, which was traditionally thought to be due to non–*K. pneumoniae* organisms; this could increase the proportion of malignancy as an underlying disease in patients with non–*K. pneumoniae*. This study found a relatively higher incidence of biliary tract disease in the *K. pneumoniae* group, which was compatible with a previous study [4]. Therefore, this study highlights an increasingly important role of *K. pneumoniae* in the pathogenesis of PLA in patients with a benign biliary tract disease.

Stewart et al found a high colonization rate in patients with biliary abnormalities or after biliary tract infection, including choledocholithiasis, chronic cholecystitis, acute cholecystitis, pancreatitis, and cholangitis [23]. In their study, the pathogens were mostly polymicrobial (57.0%), and included *Enterococcus* (21.5%), *E. coli* (16.7%), and *Klebsiella* spp. (9.6%) [24]. Thus, hepatobiliary tumor may have an effect on bile drainage similar to intrahepatic duct stone, common bile duct stone, or gallbladder stone. In addition, PLA could be a presentation of hepatopancreatobiliary malignancy at the initial or preterminal stage and has a poorer prognosis than non-hepatopancreatobiliary malignancy [24,25]. Thus, if patients are seropositive for hepatitis B or C or have chronic liver disease, marked body weight loss, or unexplained anemia, cytology should be done. Furthermore, some authors have suggested that PLA may be an indicator of silent colonic cancer [26,27]. This study found 4 patients with newly diagnosed malignancy; 1 patient with *B. fragilis* PLA had sigmoid cancer and 3 patients with *E. coli* PLA had gallbladder cancer (n = 2) or ureteral cancer (n = 1). Therefore, physicians should consider investigating

the possibility of an underlying malignancy in non–*K. pneumoniae* patients with PLA.

In the non–*K. pneumoniae* group, 7 patients (20.6%) had had gastrointestinal surgery within 2 months. This may cause a change in gastric pH level, which is important in altering the microorganisms colonizing the gastrointestinal tract [28].

This study showed a high prevalence of multidrug resistance of non–*K. pneumoniae* pathogens. The resistance of *E. coli* to first-generation cephalosporins was initially noted 20 years ago [14]. This resistance causes a higher mortality rate for non–*K. pneumoniae* PLA than for *K. pneumoniae* PLA [4]. Interestingly, this study found that inappropriate treatment did not result in a worse prognosis. Possibly early aggressive management, including aspiration drainage and/or pigtail catheter drainage, reduces the complications from PLA. Cheng et al found that early drainage was a protective factor for severe complications [29]. Thus, early drainage should be done whether or not empiric antimicrobial agents are adequate for the non–*K. pneumoniae* group.

This study found that chronic renal insufficiency is significantly associated with metastatic complications and mortality in non-diabetic patients with PLA. Yang et al found that end-stage renal disease and dialysis was a poor prognostic factor for PLA, with a mortality rate of 33%, possibly because of changes in the immune system [30]. Rupture of the abscess was also a poor prognostic factor, probably because of the abundance of tissue destruction, and extensive immunoreactions to infective and toxic substances in the abdominal cavity, although rupture may also indicate delay in seeking medical attention [31]. It was interesting to find that right lower lung infiltration was a poor prognostic factor in this study, but the cause is still unknown.

In brief, this study demonstrated that hepatobiliary tumor is an important risk factor related to non–*K. pneumoniae* liver abscess in non-diabetic patients, but malignancy was not a poor prognostic factor. Although inappropriate empirical antibiotics were given to 38.2% of patients in the non–*K. pneumoniae* group due to the high resistance rates of the organisms, this did not affect the mortality rate. This may be because of aggressive intervention in the form of drainage of the abscess. Furthermore, chronic renal failure, abscess rupture, and right lower lung infiltration might be independent factors associated with poor prognosis in non-diabetic patients with liver abscess.

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