Clinical Features and Prognosis of Gas-forming and Non-gas-forming Pyogenic Liver Abscess: A Comparative Study

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Abstract

Background Gas-forming pyogenic liver abscess (GFPLA) accounts for up to 30% of all pyogenic liver abscess (PLA) cases. However, little is known of the differences in clinical features and prognosis between GFPLA and non-GFPLA. **Aim** This retrospective study compared the clinical features and prognosis of GFPLA and non-GFPLA. **Methods** Data of 392 patients with PLA treated from 1 January 2007 to 31 December 2016 were reviewed. GFPLA was defined as gas in the abscess. Liver abscesses were considered non- GFPLA (n = 326) or GFPLA (n = 66). The clinical features and outcomes of patients with GFPLA were compared relative to that of patients without GFPLA. **Results** The groups were similar in gender ratio, age, smoking, drinking, and coexistences. *Klebsiella pneumoniae* was the most common pathogenic bacteria, but the negative rate of bacterial culture of the non-GFPLA group was significantly higher than that of the GFPLA, and the GFPLA group had a significantly higher rate of previous abdominal surgery, especially hepatobiliary surgery. Compared with the non-GFPLA group, the percentage of the GFPLA group with antibiotics combined with percutaneous drainage was significantly higher, while the percentages given antibiotics alone and antibiotics combined with surgical drainage were significantly lower. GFPLA patients had significantly higher rates of sepsis and pleural effusion, and longer hospital stays than did non-GFPLA patients. No patient died during hospitalization. **Conclusions** GFPLA is associated with past abdominal surgery, especially hepatobiliary surgery. Patients with a history of abdominal surgery should be monitored more closely in the early stage of the PLA. GFPLA has high rates of sepsis and long hospitalization. It needs to be recognized as a distinct clinical entity.

Background

Pyogenic liver abscess (PLA) is a common infectious disease of the liver, accounting for 80% of all liver abscesses [1]. Compared with the United States and Europe, the rate of incidence of PLA is higher in Asia, specifically about 17.6/100,000 in Taiwan and 1.1–3.6/100,000 in mainland China [1, 2]. The incidence of PLA has increased steadily in recent years, as it is associated with diabetes mellitus, an aging population, increasingly aggressive surgical management of hepatic, biliary, and pancreatic disorders, and the wide use of immunosuppressive agents in patients with transplant and cancer [3]. Gas-forming PLA, that is, with gas in the abscess based on ultrasound or computed tomography (CT) imaging data (Figure), may constitute as much as 30% of PLA cases [4].

GFPLA was first reported by Smith in 1944 [5]. Patients with GFPLA have a high risk of mortality, and for this it has gained attention [4]. The most common pathogen associated with PLA is *Klebsiella pneumoniae*, a Gram-negative rod-shaped bacterium with a high rate of fatality [6]. In patients with diabetes, for example, the high glucose levels may provide gas-forming microorganisms with a favorable environment for forming gas through mixed acid fermentation. In an acidic environment (pH < 6), mixed acid is metabolized by formic hydrogenlyase, resulting in gas formation [7]. Moreover, the microangiopathy associated with diabetes markedly impairs transport of catabolic end products (i.e., gas) away from the lesion, and thereby results in gas accumulation [8, 9].

However, few reports of PLA have focused on the differences in clinical features and prognoses of patients with or without gas-forming abscesses (GFPLA and non-GFPLA, respectively). This retrospective study compared the clinical features and prognoses of patients with GFPLA or non-GFPLA in our hospital.

Methods

This study was approved by the Ethics Committee of First Affiliated Hospital of Xi'an Jiaotong University (No: XJTU1AF2015LSL-057). The need for patients' informed written consent was waived due to the retrospective nature of the study.

Study population

In all, 438 patients with PLA were admitted to First Affiliated Hospital of Xi'an Jiaotong University from 1 January 2007 to 31 December 2016. Candidates with the following were excluded: 39 with incomplete history, 1 with amoeba liver abscess, 3 with tuberculosis liver abscess, and 3 younger than 18 years. The remaining 392 patients were apportioned to either the GFPLA or non-GFPLA group, according to the presence ($n = 66$) or absence ($n = 326$) of gas in the abscess, respectively. Gas-forming PLA, that is, with gas in the abscess based on Ultrasound or/and computed tomography (CT) image findings. All PLA patients received second or third generation cephalosporins combined with metronidazole or antibiotics selected according to the drug sensitivity of pus culture. Depending on the number, size, liquefaction, and separation of the abscess, response to antibiotics and the professional opinion of the doctor, the patients were given antibiotics alone, antibiotics combined with percutaneous drainage or surgical drainage [10, 11].

Data collection

A retrospective comparison and analysis was conducted of the clinical features and prognosis of patients in the GFPLA and non-GFPLA groups. Clinical data included demographic data (age and gender), lifestyle habits (smoking and drinking), coexistences, medical histories, symptoms and signs at admission, and changes during hospitalization. Laboratory data included blood routine examination and liver, renal, coagulation functions. The number, size and site of the abscess were determined by ultrasound, CT, or both. Bacterial culture included blood culture within 24 hours after admission and pus culture was executive through puncture-guided by ultrasound or CT. Treatment included antibiotics alone, antibiotics combined with percutaneous drainage or surgical drainage. Complications included sepsis, septic shock, acute kidney injury (AKI), acute respiratory distress syndrome (ARDS), spontaneous rupture of abscess, systemic inflammatory response syndrome (SIRS), pleural effusions, and portal venous thrombosis. The clinical effect was based on the days of temperature normalization after admission, length of hospital stay, and mortality in hospital.

Statistical analysis

Continuous variables were expressed as mean $\pm$ standard deviation, and categorical variables as absolute numbers and percent frequencies. Differences between continuous data were analyzed using Student's t-test. Differences between categorical data were analyzed with the chi-squared test or Fisher's exact test, as appropriate. All statistical analyses were performed with SPSS version 22.0 (IBM, Armonk, NY). A 2-tailed P value < 0.05 was considered statistically significant.

Results

Demographic data, lifestyle habits, coexistences and medical histories

Among the overall study population of 392 patients, there were 66 with GFPLA and 326 with non-GFPLA, aged 57.0 ± 13.7 and 56.7 ± 13.3 years, respectively (Table 1). The corresponding ratios of men-to-women in the two groups were 38:28 and 185:141. The GFPLA and non-GFPLA groups were statistically similar regard to gender ratio, age, smoking, drinking, and coexistences (hypertension, diabetes, hepatobiliary malignancy, lithiasis, liver cirrhosis, and viral hepatitis). A history of abdominal surgery was significantly more common in patients with GFPLA compared with non-GFPLA (62.1% vs. 41.7%; Table 1; $P = 0.002$), especially hepatobiliary surgery (50% vs. 30.3%; Table 1; $P = 0.024$). A greater percentage of the non-GFPLA group had no history of surgery compared with the GFPLA (58.3% vs. 37.9%; Table 1; $P = 0.002$). There was no significant difference in the medical history of PLA between the two groups (Table 1; $P = 0.086$).

Clinical manifestations, laboratory results, and imaging findings

Clinical manifestations

Table 2 showed that there were no significant differences in the symptoms and signs of fever, chill, abdominal pain, nausea, vomit, fatigue, body temperature, respiratory rate, or mean arterial pressure (MAP) between the two groups (Table 2). However, the heart rate of the GFPLA group (88.3 ± 13.1 bpm) was significantly faster than that of the non-GFPLA group (84.5 ± 12.8 bpm; Table 2; $P = 0.028$).

Laboratory results

Blood routine examination: As showed in table 2, the GFPLA group had significantly higher leucocytes ($13.0 \pm 6.6 \times 10^9/L$) and neutrophils ($10.9 \pm 5.9 \times 10^9/L$) than did the non-GFPLA group ($10.8 \pm 5.5 \times 10^9/L$ and $8.7 \pm 5.3 \times 10^9/L$, respectively; Table 2; $P = 0.005$ and 0.003). However, the lymphocytes, platelets, and hemoglobins of the GFPLA group were significantly lower than that of the non-GFPLA. Specifically, the count of lymphocytes in GFPLA group ($1.1 \pm 0.5 \times 10^9/L$) was significantly lower than that of the non-GFPLA group ($1.3 \pm 0.6 \times 10^9/L$; Table 2; $P = 0.007$). The count of platelets in GFPLA group ($190.9 \pm 119.4 \times 10^9/L$) was significantly lower than that of the non-GFPLA group ($230.5 \pm 125.6 \times 10^9/L$; Table 2; $P = 0.019$). The content of hemoglobins in GFPLA group (104.5 ± 18.9 g/L) was significantly lower than that of the non-GFPLA group (13.1 ± 19.1 g/L; Table 2; $P = 0.01$).

Liver and renal functions: As showed in table 2, there were no significant differences in alanine transaminase (ALT), aspartate transaminase (AST), alkaline phosphatase (ALP), glutamyl transpeptidase (GGT), total bilirubin (TBIL), direct bilirubin (DBIL), serum creatine (Cr) and blood urea nitrogen (BUN) between the two groups. However, the level of serum albumin (ALB) in the GFPLA group (28.0 ± 5.0 g/L) was significantly lower than that of the non-GFPLA group (31.4 ± 5.8 g/L; Table 2; $P < 0.001$).

Coagulation function: As showed in table 2, there were no significant differences in activated partial thromboplastin time (APTT) and fibrinogen (FIB) between the two groups. The prothrombin time (PT) of the GFPLA (15.1 ± 1.5 s) was significantly longer than that of the non-GFPLA (14.4 ± 1.9 s; Table 2; $P = 0.006$).

Image findings

As showed in table 2, the two groups were similar with regard to percentages of single or multiple abscesses. Specifically, in the GFPLA and non-GFPLA groups there were, respectively, 52 (78.8%) and 239 (73.3%) cases of single abscess, and 14 (21.2%) and 87 (26.7%) cases of multiple abscesses. However, the maximum diameter was significantly higher in the GFPLA (7.8 ± 2.8 cm) compared with the non-GFPLA (6.5 ± 2.8 cm; Table 2; $P = 0.001$). There were 57 patients in the GFPLA group and 288 in the non-GFPLA group. Among them, in the GFPLA and non-GFPLA groups there were, respectively, 11 (19.3%) and 35 (12.2%) located in the left lobe of the liver, and 39 (68.4%) and 216 (75.0%) were located in the right lobe. Seven (12.3%) GFPLA and 37 (12.8%) non-GFPLA were found in both sides of the liver lobe. And abscess site was similar in both groups.

Microbiological characteristics

Pus culture: There were similar in pus microbiological proportions (Table 3; $P > 0.05$), number of pus bacterial species (Table 3; multiple bacteria; 6.6% vs. 16.7%; $P = 0.054$) and pus negative rate (Table 3; 34.4% vs. 29.2%; $P = 0.491$) between two groups. Most of the positive bacteria in pus culture were *K. pneumoniae*, followed by *Escherichia coli*.

Blood culture: There were similar in blood microbiological proportions (Table 3; $P > 0.05$), number of blood bacterial species (Table 3; multiple bacteria; 3.1% vs. 6.3%, $P = 0.335$), most of the positive bacteria in pus culture were *K. pneumoniae*, followed by *Escherichia coli*, which were consistently with results of pus culture between two groups. However, the Non-GFPLA group had a higher blood negative rate than GFPLA group (Table 3; 77.1% vs. 56.2%, $P = 0.017$).

Treatments, complications, and outcomes

Treatments: In the non-GFPLA group, 95 (29.1%), 159 (48.8%), and 72 (22.1%) patients received routine anti-infection therapy, percutaneous transhepatic puncture drainage under the guidance of ultrasound or CT, and surgical drainage, respectively (Table 4). In the GFPLA group, these corresponding treatments were administered to 12 (18.2%), 45 (68.2%), and 9 (13.6%) patients. A significantly higher percentage of patients in the GFPLA group received antibiotics combined with percutaneous drainage compared with

the non-GFPLA, but a significantly lower percentage in the GFPLA underwent either conservative treatment or surgical drainage (Table 4; $P = 0.016$).

Complications: The GFPLA and non-GFPLA groups were similar in the occurrence of the following complications: septic shock, ARDS, spontaneous rupture of abscess, SIRS, and portal venous thrombosis (Table 4; $P > 0.05$). However, the GFPLA group had significantly higher rate of sepsis (Table 4; 21.2% vs. 9.2%; $P = 0.005$) and pleural effusion (Table 4; 51.5% vs. 31.9%) compared with the non-GFPLA.

Outcomes: The groups were similar in days for temperature normalization after admission (Table 4; 7.2 ± 6.3 vs. 8.1 ± 6.0 d; $P = 0.298$). However, the patients of the GFPLA group experienced a significantly longer hospital stay compared with the non-GFPLA (Table 4; 19.6 ± 11.6 d vs. 16.2 ± 8.8 d; $P = 0.029$). There were no deaths in either group during hospitalization.

Discussion

The clinical features and prognosis of GFPLA has not been sufficiently elucidated. Few studies have investigated the role of gas-formation in PLA [4, 9, 12, 13]. In the present study, we retrospectively compared the clinical features and outcomes of GFPLA and non-GFPLA. The analysis found that GFPLA was associated with previous abdominal surgery, especially hepatobiliary surgery. GFPLA was associated with a high rates of sepsis and long hospitalization. However, the clinical features, the prevalence of diabetes, and microbiological characteristics were similar to that of the non-GFPLA patients. More importantly, there were no major differences in the overall outcomes between the GFPLA and non-GFPLA patients.

The analysis showed that GFPLA does not differ from non-GFPLA by gender ratio, age, rates of smoking, drinking, hypertension, diabetes, hepatobiliary malignant diseases, lithiasis, liver cirrhosis, and viral hepatitis. However, GFPLA was more prevalent in patients with a history of abdominal surgery, especially hepatobiliary surgery. Lee et al. [9] reported that patients with past gastrectomy may be prone to GFPLA due to alteration of gut flora. Although our current data cannot confirm that abdominal surgery is an independent risk factor for GFPLA, it does suggest an association.

The symptoms and signs of the GFPLA and non-GFPLA groups were no statistically comparable, except that the heart rate of the patients with GFPLA was significantly higher. It has been reported that an elevated heart rate is associated with increased mortality and cardiovascular risk in patients with no significant heart disease [14]. This suggests that the higher heart rate in GFPLA may portend a poorer prognosis.

A link between type 2 diabetes and GFPLA remains controversial. In some studies, the presence of diabetes and poorly controlled blood glucose was the single strongest risk factor for GFPLA [12, 15–17], but Yang et al. [13] reported no significant difference in blood glucose levels between these patients with or without GFPLA. The latter is consistent with the present study, which found no significant difference in

the prevalence of diabetes between the two groups. However, the GFPLA group had significantly lower levels of lymphocytes, hemoglobins, platelets, and albumin compared with the non-GFPLA.

Imaging analysis showed that there was no significant difference in the site and number of abscesses between the GFPLA and non-GFPLA groups. Yet, the abscesses of the GFPLA group were usually larger (i.e., by maximum diameter). This finding is consistent with Chou et al. [12], and may be due to the expansion of the abscess with infection and gas formation.

In the present study, the composition and relative predominance of bacterial species in the blood and pus cultures were similar. *K. pneumoniae* was the most common causative organism, followed by *Escherichia coli*. This is consistent with recent literature [18]. This result may be related to the aging social structure of the population and the increased incidence of diabetes and tumors. Several studies have shown that the hyperglycemic environment and abnormal intima of diabetic patients is beneficial to *K. pneumoniae* colonization, and facilitates the spread of *K. pneumoniae* through the blood to cause PLA [19]. The negative rate of blood culture in the non-GFPLA group was higher than that of the GFPLA. The reason for this is not known.

The rate of pleural effusions in the GFPLA group was significantly higher than that of the non-GFPLA. This may be due to the adjacent anatomical relationship between the chest and the liver. The severe infection of the liver directly stimulates the diaphragm, to aggravate pleural effusions. It may also be caused by the partial destruction of liver function, the increase of portal vein pressure, and the obstruction of lymphoid reflux in the liver abscess.

In the past, abscess drainage was mainly accomplished through surgery. However, percutaneous aspiration or drainage has now become the standard of practice [20, 21]. In the current study population, 68.2% of the patients with GFPLA and 48.8% of the patients with non-GFPLA underwent antibiotics combined with percutaneous drainage, which is consistent with the above findings. However, the rate of antibiotics combined with percutaneous drainage was significantly higher in the GFPLA, and the rates of antibiotics combined with surgical drainage and antibiotics alone were lower. This may be because the patients with GFPLA showed a higher positive rate of bacteria in blood culture. It was thus easier to select sensitive antibiotics for curing the disease.

In this study, no death occurred in any patient during hospitalization, and there was no significant difference in overall short-term prognosis between the two groups. Earlier studies reported that patients with GFPLA have a high mortality rate [13, 22]. However, due to differences in the etiology, diagnosis, treatment, and prognosis of PLA, the incidence and mortality of GFPLA still needs investigation. Moreover, whether the presence of gas in the abscess has a decisive effect on the prognosis of PLA needs to be confirmed.

Several limitations of this study need to be considered. First, the data was from only a single center, and most of the patients reside in Shaanxi Province of China. Considerable differences in etiology, treatment, and outcomes of PLA have been revealed in recent studies from different parts of the world [23–25].

Therefore, our findings need to be verified by multicenter research. Secondly, this is a retrospective study and subject to selection bias and residual confounding. Finally, we only investigated the short-term results of PLA in this study. This is because the underlying disease would significantly influence the long-term outcomes of the patient. To evaluate GFPLA for higher incidence and mortality, a prospective study with propensity score matching is necessary.

Conclusions

GFPLA preferentially occurs in patients with a history of abdominal surgery, especially hepatobiliary surgery. *K. pneumoniae* is the most common pathogenic bacteria in pus or blood culture of patients with either GFPLA or non-GFPLA, while the abscess in GFPLA is larger. The GFPLA group had a higher incidence of sepsis and longer hospital stay compared with the non-GFPLA. Both GFPLA and non-GFPLA can be cured by timely and effective antibiotics alone or antibiotics combined with percutaneous drainage or surgical drainage. However, early and adequate abscess percutaneous drainage may be the optimal treatment for GFPLA.

Abbreviations

PLA, pyogenic liver abscess; GFPLA, Gas-forming pyogenic liver abscess; CT, computed tomography; MAP, mean arterial pressure; SD, standard deviation; ALT, Alanine aminotransferase; AST, Aspartate transaminase; ALP, alkaline phosphatase; GGT, gamma-glutamyl transferase; TBIL, total bilirubin; DBIL, direct bilirubin; Cr, creatinine; BUN, blood urea nitrogen; PT, prothrombin time; APTT, activated partial thromboplastin time; INR, international normalized ratio; FIB, fibrinogen; AKI, acute kidney injury; ARDS, acute respiratory distress syndrome; SIRS, systemic inflammatory response syndrome.

Declarations

Ethics approval and consent to participate: This study was approved by the Ethics Committee of the First Affiliated Hospital of Xi'an Jiaotong University (XJTU1AF2015LSL-057). The patient's informed written consent to analysis of their medical records was waived due to the retrospective nature of this study. And no further permission from the hospital was required.

Consent for publication: Not applicable.

Availability of data and material: All data generated or analysed during this study are included in this published article.

Competing interests: The authors declare that they have no competing interests.

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Authors' contributions: Wu R designed the research; Wu Z and Lv Y supported the research; Zhang J, Gao Y, Du Z, Bi J and Du Z collected the data; Zhang J analyzed the data; Wu R and Zhang J wrote the manuscript; Wu R supervised the whole research; all authors have read and agreed with the final manuscript.

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Tables

Table 1. Demographic data, lifestyle habits, coexistences and medical histories. *

		Total	Non-GFPLA	GFPLA	P value
Demographic data	Subjects, n	392	326	66	
	Male/Female, n/n	223/169	185/141	38/28	0.902
	Age, y	56.8 ± 13.4	56.7 ± 13.3	57.0 ± 13.7	0.884
Lifestyle habits	Smoking	106 (27.0)	84 (25.8)	22 (33.3)	0.207
	Drinking	65 (16.6)	56 (17.2)	9 (13.6)	0.481
Coexistences	Hypertension	77 (19.6)	61 (18.7)	16 (24.2)	0.302
	Diabetes mellitus	124 (31.6)	101 (31.0)	23 (34.8)	0.538
	Hepatobiliary malignant diseases	44 (11.2)	33 (10.1)	11 (16.7)	0.125
	Lithiasis	150 (38.3)	122 (37.4)	28 (42.4)	0.446
	Liver cirrhosis	16 (4.1)	12 (3.7)	4 (6.1)	0.582
	Viral hepatitis	29 (7.4)	22 (6.7)	7 (10.6)	0.404
Medical histories	Abdominal surgery	177 (45.2)	136 (41.7)	41 (62.1)	0.002
	Hepatobiliary	148 (37.8)	115 (35.3)	33 (50.0)	0.024
	Other	29 (7.4)	21 (6.4)	8 (12.1)	0.177
	No surgery	215 (54.8)	190 (58.3)	25 (37.9)	0.002
	PLA	42 (10.7)	31 (9.5)	11 (16.7)	0.086

* Reported as n (%), unless shown otherwise.

Table 2. Clinical features, laboratory results and imaging findings.

		Total	Non-GFPLA	GFPLA	P value
Symptoms and signs	Subjects, n	392	326	66	
	Fever	340 (87.2)	278 (85.3)	62 (93.9)	0.058
	Chill	197 (50.3)	163 (50.0)	34 (51.5)	0.822
	Abdominal pain	172 (43.9)	139 (42.6)	33 (50.0)	0.272
	Nausea	91 (23.2)	74 (22.7)	17 (25.8)	0.592
	Vomit	60 (16.3)	49 (15.0)	11 (16.7)	0.736
	Fatigue	69 (17.6)	55 (16.9)	14 (21.2)	0.398
	Body temperature, °C	37.3 ± 1.1	37.3 ± 1.1	37.5 ± 1.1	0.234
	Respiratory rate, /min	19.8 ± 1.8	19.8 ± 1.9	20.2 ± 1.7	0.051
	Heart rate, bpm	85.1 ± 12.9	84.5 ± 12.8	88.3 ± 13.1	0.028
	MAP, mmHg	90.5 ± 25.3	90.9 ± 24.6	88.8 ± 28.8	0.541
Laboratory results	Leucocytes, ×10 ⁹ /L	11.2 ± 5.7	10.8 ± 5.5	13.0 ± 6.6	0.005
	Neutrophils, ×10 ⁹ /L	9.1 ± 5.5	8.7 ± 5.3	10.9 ± 5.9	0.003
	Lymphocytes, ×10 ⁹ /L	1.3 ± 0.6	1.3 ± 0.6	1.1 ± 0.5	0.007
	Hemoglobins, g/L	111.6 ± 19.3	113.1 ± 19.1	104.5 ± 18.9	0.001
	Platelets, ×10 ⁹ /L	223.7 ± 125.3	230.5 ± 125.6	190.9 ± 119.4	0.019
	ALT, U/L	63.9 ± 98.7	63.6 ± 103.2	65.6 ± 73.5	0.878
	AST, U/L	54.9 ± 129.1	54.7 ± 139.3	55.5 ± 57.6	0.962
	ALP, U/L	195.0 ± 134.5	192.9 ± 140.2	205.5 ± 102.4	0.487
	GGT, U/L	168.7 ± 156.5	166.6 ± 161.0	178.7 ± 133.1	0.568
	TBIL, µmol/L	20.9 ± 24.7	20.1 ± 22.0	24.8 ± 35.2	0.163
	DBIL, µmol/L	11.2 ± 17.4	10.6 ± 16.5	13.9 ± 21.1	0.165
	ALB, g/L	30.8 ± 5.8	31.4 ± 5.8	28.0 ± 5.0	<0.001
	Cr, µmol/L	67.1 ± 47.4	66.8 ± 50.3	68.8 ± 28.4	0.764
	BUN, mmol/L	5.2 ± 3.1	5.1 ± 3.1	5.8 ± 2.6	0.061
	PT, s	14.5 ± 1.8	14.4 ± 1.9	15.1 ± 1.5	0.006
	APTT, s	39.0 ± 5.9	39.0 ± 6.1	39.0 ± 5.2	0.996
	FIB, g/L	5.9 ± 1.9	5.9 ± 1.9	5.9 ± 1.9	0.812
Imaging findings	Abscess number				
	Single lesion	291 (74.2)	239 (73.3)	52 (78.8)	0.354
	Multiple lesions	101 (25.8)	87 (26.7)	14 (21.2)	
	Abscess size, cm ^b	6.7 ± 2.8	6.5 ± 2.8	7.8 ± 2.8	0.001
	Abscess site, Subjects, n	345	288	57	
	Left lobe abscess	46 (13.3)	35 (12.2)	11 (19.3)	0.348
	Right lobe abscess	255 (73.9)	216 (75.0)	39 (68.4)	
	Both-lobe abscesses	44 (12.8)	37 (12.8)	7 (12.3)	

^a Reported as n (%), unless shown otherwise; ^b maximum diameter;

Table 3. Microbiological characteristics. *

		Total	Non-GFPLA	GFPLA	P value
Pus culture	Positive, n	231	183	48	
	K. pneumoniae	79 (34.2)	68 (37.2)	11 (22.9)	0.064
	Escherichia coli	24 (10.4)	15 (8.2)	9 (18.8)	0.062
	Enterococcus	7 (3.0)	7 (3.8)	Nil	0.367
	Streptococcus	8 (3.5)	6 (3.3)	2 (4.2)	1
	Staphylococcus	4 (1.7)	3 (1.6)	1 (2.1)	1
	Enterobacter aerogenes	1 (0.4)	1 (0.5)	Nil	1
	Other	11 (4.8)	8 (4.4)	3 (6.3)	0.870
	Multiple bacteria	20 (8.7)	12 (6.6)	8 (16.7)	0.054
Blood culture	No growth	77 (33.3)	63 (34.4)	14 (29.2)	0.491
	Positive, n	163	131	32	
	K. pneumoniae	14 (8.6)	11 (8.4)	3 (9.4)	1
	Escherichia coli	8 (4.9)	6 (4.6)	2 (6.3)	1
	Enterococcus	2 (1.2)	1 (0.8)	1 (3.1)	0.355
	Streptococcus	4 (2.5)	2 (1.5)	2 (6.3)	0.173
	Staphylococcus	4 (2.5)	3 (2.3)	1 (3.1)	1
	Enterobacter aerogenes	1 (0.6)	1 (0.8)	Nil	1
	Other	5 (3.1)	2 (1.5)	3 (9.4)	0.052
	Multiple bacteria	6 (3.7)	4 (3.1)	2 (6.3)	0.335
	No growth	119 (73.0)	101 (77.1)	18 (56.3)	0.017

* Reported as n (%), unless shown otherwise.

Table 4. Treatments, complications and outcomes.

		Total	Non-GFPLA	GFPLA	P value
Treatments	Subjects, n	392	326	66	
	Antibiotics alone	107 (27.3)	95 (29.1)	12 (18.2)	0.016
	Antibiotics combined with percutaneous drainage	204 (52.0)	159 (48.8)	45 (68.2)	
	Antibiotics combined with surgical drainage	81 (20.7)	72 (22.1)	9 (13.6)	
Complications	Sepsis	44 (11.2)	30 (9.2)	14 (21.2)	0.005
	Septic shock	3 (0.8)	2 (0.6)	1 (1.5)	0.426
	ARDS	4 (1.0)	2 (0.6)	2 (3.0)	0.133
	AKI	1 (0.3)	1 (0.3)	Nil	1
	SIRS	140 (35.7)	110 (33.7)	30 (45.5)	0.070
	Spontaneous rupture of abscess	3 (0.8)	1 (0.3)	2 (3.0)	0.075
	Pleural effusion	138 (35.2)	104 (31.9)	34 (51.5)	0.002
	Portal venous thrombosis	3 (0.8)	2 (0.6)	1 (1.5)	0.426
Outcomes	Temperature normalization, d	7.4 ± 6.3	7.2 ± 6.3	8.1 ± 6.0	0.298
	Length of hospital stay, d	16.8 ± 9.4	16.2 ± 8.8	19.6 ± 11.6	0.029
	Mortality in hospital	Nil	Nil	Nil	

* Reported as n (%), unless shown otherwise.

Figures

Figure 1

Abdominal CT findings of GFPLA. Arrows: GFPLA.