Klebsiella pneumoniae Liver Abscess: An Emerging Disease

Tasaduq Fazili, MD, Calden Sharngoe, MD, Timothy Endy, MD, Deana Kiska, MS, PhD, Waleed Javaid, MD and Mark Polhemus, MD

ABSTRACT

Most of the cases of *Klebsiella pneumoniae* liver abscess reported early on were from Asia, predominantly Taiwan, with a significant number of patients being middle aged diabetic men, and developing metastatic complications, especially endophthalmitis. The entity is now being increasingly recognized in the United States. In this article, the authors review those reported cases, and also the literature regarding the pathophysiology of this intriguing syndrome.

Key Indexing Terms: *Klebsiella pneumoniae*; Liver abscess; United States; Emerging disease; Hyperviscous phenotype.
[Am J Med Sci 2016;351(3):297–304.]

INTRODUCTION

Liver abscess is a relatively common infection caused by a variety of bacterial, fungal and parasitic pathogens. Until recently, *Escherichia coli* was the most common etiologic agent of pyogenic liver abscesses but starting in the mid 1980s, increasing case reports of *Klebsiella pneumoniae* liver abscess (KLA) began appearing in the literature. Most of these infections were reported from Taiwan. The patients were middle-aged men with diabetes, with a significant number of them developing bacteremia and metastatic complications, especially endophthalmitis. In the past decade, several cases of KLA have been reported from the United States, with a somewhat similar disease spectrum. We review all the cases that have been reported in the United States so far, and also explore the pathophysiologic mechanisms of this unique disease process.

METHODS

We reviewed all the published case reports in the literature of KLA in the United States. This was done by performing a PubMed search, using keywords *Klebsiella* and liver abscess. Altogether, 34 cases and case series were identified and included in the review. The period of the reviewed articles was from 1949 to date.

RESULTS

Including our case, we found a total of 93 cases of KLA in the United States (Table). Excluding 1 newborn, all the patients were adults. The age range was from 28-78 years, with a mean age of 53 years. The male-to-female ratio was approximately 3:1. The most common underlying conditions that were reported were diabetes (18 patients), hypertension (14 patients), biliary disease (10 patients) and coronary artery disease (2 patients).

Among the patients with ethnicity reported, the distribution was as follows: Asian (39 patients), Hispanic (16 patients), White (12 patients), African-American (4 patients) and Hawaiian (2 patients).

In patients who had the location of the abscess reported, the right lobe of the liver was more commonly affected (34 patients with single lesion and 7 patients with multiple lesions). The left lobe was less frequently involved (5 patients with single lesion and 4 patients with multiple lesions), whereas multiple lesions in both the lobes were reported only in 4 patients.

Cultures were positive from the liver abscess in 73 (78%) patients, blood in 43 (46%) patients and both blood and liver abscess in 27 (29%) patients. Other less frequently involved sites with positive cultures were the cerebrospinal fluid (4 patients), vitreous (3 patients), urine (2 patients) and sputum, soft tissue abscess of the neck and mitral valve (1 patient each). Only 7 patients had a polymicrobial infection, and the other bacteria involved were *Enterococcus fecalis* and *Clostridium perfringens.* The serotypes of the isolates were unknown for most patients (85 patients). Among the 8 patients in whom serotyping was done, 4 patients were reported as K-1 positive, 2 patients as K-2 positive and 1 each patient as K-29 and *Rmp A* positive.

In the pre-1970 era, the antibiotics used were streptomycin, and penicillin or ampicillin with gentamicin. In the post-1970 era, the most frequently used combination was ceftriaxone and metronidazole. From the 1990s onwards, a quinolone with metronidazole was the next most common combination used.

Complications were not infrequently encountered in the patients in our review. The reported complications were endophthalmitis (7 patients), meningitis (6 patients), septic emboli to the lungs (4 patients) and pneumonia (2 patients). Less frequently encountered complications were renal abscess, lung abscess, septic emboli to brain, brain abscess, endocarditis, hepatobronchial fistula and tibial osteomyelitis (1 patient each). Of the 7 patients who had endophthalmitis, 3 patients required

TABLE. Case reports of liver abscesses due to *Klebsiella pneumoniae.*

Case no.	Ref.	Age (years)	Sex/ ethnicity	Underlying condition/risk factor	Location of liver abscess	Positive cultures	Serotype	Antibiotic treatment	Procedure	Complications	Outcome
1	1	60	F/white	Unknown	R lobe, single	Blood, liver, CSF	Unknown	Streptomycin	None	Meningitis	Died
2	2	51	F/white	Diabetes	R lobe, single	Blood, CSF	Unknown	Streptomycin/ sulfadiazine	None	Meningitis	Died
3	3	Newborn	F/white	Umblical vein catheterization	Unknown	Blood, CSF	Unknown	Unknown	None	Meningitis	Died
4	4	48	M/black	Unknown	R lobe, single	Liver	Unknown	Unknown	Open drainage	Tibial osteomyelitis	Survived
5	5	70	F/white	Pancreatic cancer s/p Whipple procedure	Diffuse hepatitis	Blood, liver	Unknown	Penicillin/gentamicin	Surgical exploration with liver biopsies	None	Survived
6	6	68	F/hispanic	Diabetes, HTN, CHF	L lobe, multiple	Liver	Unknown	Ampicillin/ gentamicin	Open drainage	None	Survived
7	7	33	M/white	Unknown	R lobe, single	Liver	Unknown	Unknown	Percutaneous drainage	None	Survived
8	8	37	M/white	Hemorroidectomy	L lobe, single	Blood, liver	Unknown	Penicillin/ gentamicin/ metronidazole	Percutaneous drainage	None	Survived
9	9	50	M/white	Choledocholithiasis	Both lobes, multiple	Blood	Unknown	Cefazolin	Common bile duct stent	None	Survived
10–14	10	Unknown	Unknown	"Benign biliary disease" (1)	Unknown	Not specified	Unknown	Not specified	Not specified	Not specified	Not specified
				"Malignant biliary disease" (2)							
				Pancreatitis (1)							
				Unknown (1)							
15	11	61	M/not specified	None	R lobe, single	Blood, liver	Unknown	Ceftizoxime/	Percutaneous drainage	Pneumonia	Survived
								Metronidazole		Endophtalmitis	(Needed eye prosthesis)
16	12	38	M/black	Diabetes	R lobe, single	Liver, CSF	Unknown	Ceftriaxone/	Percutaneous drainage	Meningits	Survived
								Metronidazole, then		Endophthalmitis	
								Levofloxacin/ Metronidazole			
17	13	32	M/not specified	Beta-thalassemia major	R lobe, multiple	Liver, vitreous	Unknown	Ceftriaxone/	Percutaneous drainage	Subretinal abscess	Survived
				Splenomegaly				Gentamicin/	Vitrectomy, retinectomy	Renal abscess	(Vision 20/30)
								Metronidazole, then Ciprofloxacin			

(continued on next page)

TABLE. *(continued)*

Case no.	Ref.	Age (years)	Sex/ ethnicity	Underlying condition/risk factor	Location of liver abscess	Positive cultures	Serotype	Antibiotic treatment	Procedure	Complications	Outcome
18	14	57	M/black	Diabetes, cystic duct obstruction	Both lobes, multiple	Blood, liver	Unknown	Ciprofloxacin/	Open drainage	None	Survived
								Clindamycin	Cholecystectomy		
19	15	29	M/not specified	None	R lobe, single	Blood, liver	Unknown	Piperacilin/ tazobactam	Percutaneous drainage	None	Survived
20	16	62	M/white	Diabetes	R lobe, single	Blood, liver	Unknown	Ciprofloxacin/ imipenem	Percutaneous drainage	None	Survived
21–43	17	Not specified	Asian/hispanic	Not specified	Not specified	Liver	Unknown	Varied	Not specified	None	Overall 2.5% mortality
44	18	62	M/white	Diabetes	R lobe, single	Blood, liver	K-1	Quinolone	Percutaneous drainage	None	Survived
45–50	19	50–71	4 Men/2 women								
			2 White	Coronary artery disease	L lobe, single (2)	Blood, liver (2)	Unknown	Cephalosporin/	Percutaneous drainage	None	Survived
			4 Filipino	Diabetes, CAD, HTN	Both lobes, multiple (1)	Blood, liver (3)		metronidazole	in all 6 patients		
					L lobe, multiple (1)	Liver (1)					
					L lobe, single (1)			Quinolone/			
					R lobe, single (1)			metronidazole			
51–52	20	49	M/Hawaiian	Diabetes	R lobe, single	Liver	Unknown	Ciprofloxacin/ metronidazole	Percutaneous drainage	Septic shock	Survived
		56	M/Hawaiian	Diabetes	Both lobes	Liver	Unknown	Ceftriaxone/ metronidazole, then Amoxicillin-clavulanate	Percutaneous drainage	None	Survived
53	21	65	M/not specified	Acute lymphocytic leukemia	Both lobes, multiple	Liver	Unknown	Cefepime	Percutaneous drainage	None	Survived
54	22	49	M/not specified	Not specified	R lobe, single	Liver	Unknown	Ceftriaxone/ ciprofloxacin/ metronidazole	Percutaneous drainage	Hepatobronchial fistula	Survived
55	23	42	M/Filipino	None	R lobe, single	Liver, CSF	Unknown	Ceftriaxone/ metronidazole	Percutaneous drainage	Meningitis	Survived
										Septic emboli to brain and lung	
56	24	42	M/Viet-namese	Diabetes	R lobe, multiple	Liver, blood, sputum, urine, neck abscess	K-1	Imipenem/ levofloxacin	Percutaneous drainage	Neck abscess	Survived
										Lung abscess	

(continued on next page)

TABLE. *(continued)*

Case no.	Ref.	Age (years)	Sex/ ethnicity	Underlying condition/risk factor	Location of liver abscess	Positive cultures	Serotype	Antibiotic treatment	Procedure	Complications	Outcome
57	25	43	M/Haitian	None	R lobe, single	Liver, vitreous	Unknown	Gatifloxacin	Percutaneous drainage	Endopthalmitis	Survived
										Preseptal abscess	(Required enucleation)
58–77	26	Median 56.5	14 Men, 6 Women	Hypertension (9)	R lobe, single (15)	Blood (13)	Unknown	Ceftriaxone	Percutaneous drainage	Emboli to lungs (4)	Survived (18)
			12 Asian descent	Diabetes (5)	L lobe, single (1)	Liver (14)		Ciprofloxacin	(16 Patients)	Meningitis (1)	Died (2)
			8 Hispanic descent	Biliary disease (5)	R lobe, multiple (2)	Blood and liver (8)			Open drainage	Endophthalmitis (1)	
				None (4)	L lobe, multiple (2)				(2 Patients)	Pneumonia (1)	
78	27	28	M/not specified	None	R lobe, multiple	Blood, liver	Unknown	Ceftriaxone	None	Septic emboli to lungs	Survived
79	28	51	M/not specified	None	Not specified	Blood, liver, vitreous, urine	Unknown	Not specified	Percutaneous drainage	Endophthalmitis	Survived
											(Required enucleation)
80	29	49	M/Afro-Caribbean	None	R lobe, multiple	Liver, blood	K-2	Ceftriaxone	Percutaneous drainage	Brain abscesses	
81–87	30	Not specified	Not specified	Not specified	Not specified	Liver	Rmp+	Not specified	Not specified	Not specified	Not specified
88	31	39	M/Filipino	None	R lobe, single	Liver, mitral valve	K-2	Ceftriaxone	Mitral valve replacement	Endophthalmitis	Survived
										Endocarditis	
										Septic emboli to lungs	
89	32	58	F/not specified	None	R lobe, single	Liver	Unknown	Piperacillin-tazobactam, then ciprofloxacin	Percutaneous drainage	None	Survived
90	33	78	M/not specified	DM, HTN, PAD, A Fib,	R lobe, single	Liver	K-1	Ceftriaxone	Percutaneous drainage	None	Survived
91–92	34	53	F/African-American	Not specified	Not specified	Liver	K-29	Not specified	Not specified	None	Survived
		52	M/Chinese	Diabetes, HTN	R lobe, single	Liver, blood	K-1	Not specified	Not specified	None	Survived
93	Our case	68	M/Bangladeshi	Diabetes, HTN, prostate cancer	R lobe, multiple	Liver, blood	Unknown	Ceftriaxone/ metronidazole	Percutaneous drainage followed by R lobe lobectomy	Multiorgan failure	Died

A Fib, atrial fibrillation; CAD, coronary artery disease; CHF, congestive heart failure; CSF, cerebrospinal fluid; DM, diabetes mellitus; HTN, hypertension; PAD, peripheral artery disease.

surgical intervention (enucleation/eye prosthesis). The overall mortality was 7%. However, 2 of the patients who died were from early case reports (late 40s-early 50s).

DISCUSSION

Pyogenic liver abscess can be either bacterial or fungal in etiology. In the developed world, pyogenic liver abscess constitutes three-fourths of all liver abscesses, with an incidence of 1 in every 4,500–7,000 hospital admissions.[19] There are several routes via which infection can reach the liver, leading to the development of an abscess. These include the portal vein, biliary tree, hepatic artery, direct extension of infection and penetrating trauma. In the pre- and early antibiotic era, pylephlebitis due to abdominal visceral infection, especially appendicitis, was the most common cause of liver abscess formation. Appendicitis rarely causes liver abscess now because of the use of early, broad-spectrum antibiotics. Biliary tract infection is now the leading cause of secondary bacterial liver abscess. Infections like diverticulitis, colitis and pancreatitis continue to remain important causes, although the incidence of liver abscesses due to these appears to be decreasing. In a significant number of patients, no cause is apparent. These primary cryptogenic abscesses have been reported as the predominant category in several case series.

Up to the 1980s, *E. coli* was the most common etiologic agent, usually found in the setting of a polymicrobial infection with a bowel or biliary source. Beginning in the mid 1980s, primary liver abscesses without intra-abdominal or biliary tract infection began to be reported in the literature.[35] The patients were mostly middle-aged Southeast-Asian men, with a significant number having underlying diabetes or impaired glucose tolerance. Bacteremia and metastatic complications were frequent, especially endophthalmitis and meningitis.[36] KLA has since been reported from several other countries including Korea, Singapore, Thailand, Japan, Spain, England and Australia. Cases have been reported from the United States sporadically but the frequency seems to have increased over the past 2 decades.

We reviewed all cases of KLA reported in the United States so far and found a total of 93 patients. Almost half of the patients were of Asian descent and only a small fraction of patients were White. A smaller percentage of patients in our review had diabetes compared to the studies from Vietnam. The mean age, male-to-female ratio, predominance of the right lobe of the liver, bacteremia, metastatic complications (especially meningitis and endophthalmitis) and mortality were similar to those reported in the Vietnamese studies.[35,36]

Serotyping data were available only in a small number of patients; most of them had the K1/K2 serotype. The treatment modality used uniformly was percutaneous drainage accompanied by antibiotics. A third generation cephalosporin and metronidazole was the preferred regimen both in the United States and Vietnam, whereas several patients in the United States (in the last 2 decades) were treated with a fluoroquinolone and metronidazole. Our patient was male, diabetic and of Asian descent. His liver abscess seems to have been the primary source of infection without any other obvious foci or metastatic complications like meningitis and endophthalmitis. Unfortunately, serotyping could not be performed. As our review included cases over a long period of time, it is possible that there could have been bias in certain characteristics, like the incidence of underlying diabetes and other chronic medical comorbidities, as well as the ethnicity of the patients.

KLA seems to be a unique syndrome that is being increasingly recognized worldwide. It is frequently complicated by bacteremia, sepsis and metastatic spread of infection. As mentioned earlier, most of the early cases were reported from Taiwan. In a large series, Wang et al[37] retrospectively reviewed a total of 182 cases of pyogenic liver abscess in Taiwan from 1990–1996. Of these, 160 cases were due to *K. pneumoniae* alone and 22 cases were polymicrobial. As compared to patients with polymicrobial infection, the authors found patients with KLA to have increased incidence of diabetes or glucose intolerance (75% versus 4.5%) and metastatic infection (11.9% versus 0%), and lower rate of intra-abdominal abnormality (0.6% versus 95.5%), relapse (4.4% versus 41%) and mortality (11.3% versus 41%). A subsequent study, also from Taiwan, showed similar results.[38] Out of a total of 248 cases of pyogenic liver abscesses, *K. pneumoniae* was the causative agent in 171 (69%) cases. Abscesses caused by *K. pneumoniae* were found to have a stronger association with diabetes or impaired fasting glucose (70% versus 32%), metastatic infection (14% versus 4%) and lower mortality (4% versus 21%).

The pathogenesis of the KLA syndrome is still not completely understood. One of the leading host factors that has been implicated is diabetes or impaired glucose tolerance. Most studies have reported a high prevalence of diabetes or impaired glucose tolerance, some of them of more than 70%, although this is not universal. Impaired glycemic control is believed to result in decreased neutrophil phagocytosis, especially of K1 and K2 capsular serotypes.

Fatty liver has also been reported more frequently with KLA than with liver abscesses due to other bacteria, although this association is not as strong as diabetes or impaired glucose tolerance.[39]

Given the high prevalence of KLA in Asians and patients living in other countries of Asian descent, a genetic predisposition to KLA is suspected, although not proven. Chinese ethnicity might be associated with a higher likelihood of intestinal colonization with *K. pneumoniae* isolates of the K1 and K2 serotypes. In a study examining *K. pneumoniae* from the stool of healthy Chinese adults living in 8 different Asian countries, K1 and K2 serotypes accounted for 10% of the isolates.[40] Obviously, more research is needed to derive conclusive inferences in this regard.

There are 77 capsular polysaccharide (CPS) antigens of *K. pneumoniae.* The K1 and to a lesser degree, K2 strains are thought to be the most virulent, and have been the most frequently reported in KLA. The following virulence factors have been implicated: (1) thick encapsulation of K1 and K2 strains, (2) resistance to phagocytosis, (3) *magA* (mucoviscosity associated gene A) and (4) *rmpA* (regulator of mucoid phenotype A gene).

Animal studies carried out approximately 20 years ago revealed that CPS (K antigen) is the main virulence factor for *K. pneumoniae.*[41,42] Serotypes K1 and K2 were found to be the most virulent in these animal models. Fung et al[43] were the first to demonstrate similar findings in humans. They reviewed 134 cases of KLA in Northern Taiwan from 1991–1998. Serotyping of the isolates revealed that K1 (85/134; 63%) and K2 (19/134; 14%) were the most common. Septic endophthalmitis was reported in 14 (10%) of the 134 patients. K1 serotype was found in 85% of these patients (12/14) and K2 in 14% (2/14). Liver, blood and vitreous cultures revealed the same serotype in all 14 cases.

Fang et al[44] reported a study of 177 patients with KLA at a tertiary university hospital in Taiwan from 1997–2005. Septic ocular or central nervous system complications were found in 23 (13%) patients. Presence of serotype K1 was the only significant risk factor for the development of these complications. K1 isolates were found to be significantly more virulent than non-K1 isolates based on serum resistance assays. Other than the serotype-specific CPS synthesis (*cps*) region, the genomic background of the K1 strains also differed compared to non-K1 strains (presence of 20-kb *kfu*/PTS region in the K1 strains). In the 19 cases in which K1 strains caused complications, 8 (42%) patients had no underlying medical disease, suggesting that this serotype can cause metastatic complications even in otherwise healthy individuals.

To elucidate the role of CPS in KLA and the development of metastatic endophthalmitis, Lin et al[45] studied neutrophil phagocytosis of 70 CPS isolates (K1 [$n = 23$], K2 [$n = 10$] and non-K1/K2 [$n = 37$]), using flow cytometry, fluorescence imaging and electron microscopy. These isolates had been previously obtained from patients with systemic infections, including liver abscess. The authors found that the K1/K2 isolates were more resistant to phagocytosis and showed increased resistance to intracellular killing, which likely leads to their increased propensity for liver abscess and endophthalmitis.

K. pneumoniae isolates causing the KLA syndrome exhibit a hypermucoviscosity phenotype. This is evident in the microbiology laboratory by the presence of mucoid colonies and the "string sign" on culture plates. The chromosomal *magA* gene and the plasmid-mediated *rmpA* gene are believed to be responsible for this phenotype.

Chuang et al[46] tried to ascertain the genetic determinants of K1 serotype causing KLA. A total of 35 of 42 isolates from patients with KLA were *magA* positive, whereas only 1 of 32 non-KLA isolates was *magA* positive. All the 36 *magA*-positive strains were serotype K1, whereas none of the *magA*-negative strains were of the K1 serotype. Sequencing of the *magA* flanking region revealed a *cps* region containing 20 open-reading frames; of these, 9 isolates were cotranscribed as part of an operon. The authors hypothesized that an operon containing *magA* is responsible for capsular serotype K1 and that several loci in the operon are determinants of this particular serotype.

In addition to *magA*, there is evidence that *rmpA* also contributes to the hyperviscous phenotype and virulence of K1 serotypes. In the earlier mentioned study by Fang et al,[44] K1 strains had a higher mean number of *rmpA* copies per strain than non-K1 isolates. Yu et al[47] looked at 151 *K. pneumoniae* blood stream isolates, and found the prevalence of hypermucoviscosity, *rmpA* and *magA* to be 38% (58 of 151 isolates), 48% (72 of 151 isolates) and 17% (26 of 151 isolates), respectively. Of the 58 hypermucoviscosity-positive isolates, 52 (90%) isolates were *rmpA* positive and 17 (29%) isolates were *magA* positive.

Hyperviscosity was predicted by 52 (72%) of 72 of the *rmpA*-positive strains and 17 (65%) of 26 of the *magA*-positive strains. Presence of *rmpA* and *magA* in the same isolate increased the expression of the hypermucoviscous phenotype. This study suggests that *rmpA* could be responsible for the hypermucoviscosity phenotype in *magA*-negative isolates like K2 and other non-K1 strains.

To explore the correlation of capsular serotype, *magA* and *rmpA* with virulence, Yeh et al[48] reviewed 73 KLA isolates from Singapore and Taiwan. The most common serotypes were K1 (34/73; 47%) and K2 (15/73; 20%). As expected, *magA* was present only in the K1 isolates. All K1 and K2 isolates, and two-thirds of the non-K1/K2 isolates carried *rmpA.* K1 and K2 isolates showed more virulence and phagocytic resistance than *rmpA*-positive and *rmpA*-negative non-K1/K2 isolates. These findings suggest that capsular serotype K1 or K2, rather than *magA* and *rmpA,* plays a more important role in virulence of *K. pneumoniae* causing liver abscess.

A more recent study tried to elucidate predictors of septic metastatic infection and mortality in patients with KLA.[49] The presence of *rmpA*, Acute Physiologic and Chronic Health Evaluation II score ≥ 20, and septic shock were significant risk factors for metastatic infection. In addition, the authors found the following to be predictors of mortality: metastatic infection, Acute Physiologic and Chronic Health Evaluation II score ≥ 16, septic shock, acute respiratory failure and presence of gas on abdominal imaging.

KLA with metastatic infection is a unique syndrome initially described in Southeast Asia, with increasing number of cases now being reported in the United States. Diabetes seems to be a less prominent risk factor in the United States. Hypermucoviscosity and serotypes K1/K2 with presence of *rmpA* and *magA*

genes appear to be most commonly associated with this syndrome. Septic ocular and central nervous system complications are frequently encountered, which can lead to significant morbidity. The disease pattern appears to be similar to that reported in Southeast Asia. It is still somewhat unclear whether there is a genetic predisposition in patients of Asian ancestry to the KLA syndrome, even if they have lived in the United States. Nonetheless, physicians in the United States need to be aware of this syndrome to optimize management.

REFERENCES

1. **Sadusk J, Relman A, Wagner R, et al.** Friedlander's bacillus meningitis treated with streptomycin. Am J Med 1949;6:522–9.
2. **DiFiglia S, Cramer C.** Friedlander's bacillus meningitis in a case with liver abscess and recurrent bacteremia and analysis of cases receiving specific therapy. NY State J Med 1951;51(6):761–5.
3. **Fraga J, Bartolome J, Venkatessan S.** Liver abscess due to *Klebsiella pneumoniae* in a new born. Clin Pediatrics 1974;12:1081–2.
4. **Goldman J, Kowalec J.** Hepatic abscess and osteomyelitis from *Klebsiella pneumoniae*. J Am Med Assoc 1978;240:2660.
5. **Freeny P.** Acute pyogenic hepatitis: sonographic and angiographic findings. Am J Radiol 1980;135:388–91.
6. **Salky B, Kaynon A, Bauer J, et al.** Ruptured hepatic abscess: a rare cause of spontaneous pneumoperitoneum. Am J Gastroenterol 1982; 77(11):880–1.
7. **Ridker P, Gregory E, Lifton R False.** Positive mononucleosis screening test results associated with *Klebsiella* hepatic abscess. Am J Clin Pathol 1990;94:222–3.
8. **Parikh S, Molinelli B, Dailey T.** Liver abscess after hemorrhoidectomy: report of two cases. Dis Colon Rectum 1994;37:185–9.
9. **Edelman K.** Multiple pyogenic liver abscesses communicating with the biliary tree: treatment by endoscopic stenting and stone removal. Am J Gastroenterol 1994;89(11):2070–2.
10. **Brook I, Frazier E.** Microbiology of liver and spleen abscesses. J Med Microbiol 1998;47:1075–80.
11. **Nye A, Kirchner J, Lamendola C.** Progressive vision loss after pneumonia. Hosp Pract 1999;34(11):150–2,157–8.
12. **Saccente M.** *Klebsiella pneumoniae* liver abscess, endophthalmitis and meningitis in a man with newly recognized diabetes mellitus. Clin Infect Dis 1999;29:1570–1.
13. **Harris E, Donald D, Bhisitkul R, et al.** Bacterial subretinal abscess: a case report and review of the literature. Am J Ophthalmol 2000;129: 778–85.
14. **Ayinala S, Vulpe M, Azaz M, et al.** Pyogenic liver abscesses due to *Klebsiella pneumoniae* in a diabetic patient. J MSMA 2001;42(3):67–70.
15. **Roeder B, Patel R.** 29-Year-old man with fever, malaise and abdominal pain. Mayo Clin Proceed 2001;76(8):841–4.
16. **Kim D, Pratt D.** Klebsiella liver abscess. Mayo Clin Proceed 2003;36(2): 186–7.
17. **Rahimian J, Wilson T, Oram V, et al.** Pyogenic liver abscess: recent trends in etiology and mortality. Clin Infect Dis 2004;39:1654–9.
18. **Fang F, Sandler N, Libby S.** Liver abscess caused by *magA*$^{+}$ *Klebsiella pneumoniae* in North America. J Clin Microbiol 2005;43(2):991–2.
19. **Lederman E, Crum N.** Pyogenic liver abscess with a focus on *Klebsiella pneumoniae* as a primary pathogen: an emerging disease with unique clinical characteristics. Am J Gastroenterol 2005;100:322–31.
20. **Harris P, Laczek J, Polish R, et al.** Two cases of *Klebsiella pneumoniae* primary liver abscesses: an emerging clinical entity among diabetics. Hawaii Med J 2005;64:306–7.
21. **Golia P, Sadler M.** Pyogenic liver abscess: *Klebsiella* as an emerging pathogen. Emerg Radiol 2006;13:87–8.
22. **Moawad F, Truesdell A, Mulhall BA.** "Fishy" cough: hepatobronchial fistula due to a pyogenic liver abscess. New Zealand Med J 2006; 119(1231):1906–9.
23. **Braiteh F, Golden M.** Cryptogenic invasive *Klebsiella pneumoniae* liver abscess syndrome. Int J Infect Dis 2007;11:16–22.
24. **Nadasy K, Domiati-Saad R, Tribble M.** Invasive *Klebsiella pneumoniae* syndrome in North America. Clin Infect Dis 2007;45:e25–8.
25. **Connell N, Thomas I, Sabharwal A, et al.** *Klebsiella pneumoniae* endophthalmitis with associated hepatic abscess. J Hosp Med 2007;2: 442–4.
26. **Pastagia M, Arumugam V.** *Klebsiella pneumoniae* liver abscess in a public hospital in Queens, New York. Travel Med Infect Dis 2008;6: 228–33.
27. **Pope J, Teich D, Clardy P, et al.** *Klebsiella pneumoniae* liver abscess: an emerging problem in North America. J Emer Med 2008;41(5): e103–5.
28. **Dodson D, Stewart R, Karcioglu Z, et al.** *Klebsiella pneumoniae* endophthalmitis secondary to liver abscess presenting as acute iridocyclitis. Ophthalmic Surg Lasers Imaging 2009;40:522–3.
29. **Doud M, Grimes-Zeppegno R, Molina E, et al.** A k_2A-positive *Klebsiella pneumoniae* causes liver and brain abscess in a Saint Kitt's man. Int J Med Sci 2009;6(6):301–4.
30. **McCabe R, Lambert L, Frazee B.** Invasive *Klebsiella pneumoniae* infections, California, USA. Emer infect Dis 2010;18(9):1490–1.
31. **Rivero A, Gomez E, Alland D, et al.** K2 serotype *Klebsiella pneumoniae* causing a liver abscess associated with infective endocarditis. J Clin Microbiol 2010;48(2):639–41.
32. **Nazir N, Penfield J, Hajjar V.** Pyogenic liver abscess. Cleveland Clinic J Med 2010;77(7):426–7.
33. **Fierer J, Walls L, Chu P.** Recurring *Klebsiella pneumoniae* pyogenic liver abscesses in a resident of San Diego, California due to a K1 strain carrying the virulence plasmid. J Clin Microbiol 2011;49(2):4371–3.
34. **Abate G, Koh T, Gardner M, et al.** Clinical and bacteriologic characteristics of *Klebsiella pneumoniae* causing liver abscess with less frequently observed multi-locus sequences type, ST 163, from Singapore and Missouri. J Microbiol Immunol Infect 2012;45:31–6.
35. **Liu Y, Cheng D, Lin C.** *Klebsiella pneumoniae* liver abscess associated with septic endophthalmitis. Arch Intern Med 1986;146:1913–6.
36. **Chang F, Chou M.** Comparison of pyogenic liver abscesses caused by *Klebsiella pneumoniae* and non-*K. pneumoniae* pathogens. J Formos Med Assoc 1995;94:232–7.
37. **Wang J, Liu Y, Lee S, et al.** Primary liver abscess due to *Klebsiella pneumoniae* in Taiwan. Clin Infect Dis 1998;26:1434–8.
38. **Yang C, Yen C, Ho M, et al.** Comparison of pyogenic liver abscess caused by non-*Klebsiella pneumoniae* and *Klebsiella pneumoniae*. J Microbiol Immunol Infect 2004;37:176–84.
39. **Li J, Fu Y, Wang JY.** Early diagnosis and therapeutic choice of *Klebsiella pneumoniae* liver abscess. Front Med China 2010;4:308.
40. **Lin YT, Siu LK, Lin JC.** Seroepidemiology of *Klebsiella pneumoniae* colonizing the intestinal tract of healthy Chinese and overseas Chinese adults in Asian countries. BMC Microbiol 2012;12:13.
41. **Mizuta K, Ohta M, Mori M.** Virulence for mice of *Klebsiella* strains belonging to the O1 group: relationship to their capsular (K) types. Infect Immunol 1983;40:56–61.
42. **Nassif X, Sansonetti P.** Correlation of the virulence of *Klebsiella pneumoniae* K1 and K2 with the presence of a plasmid encoding aerobactin. Infect Immunol 1986;54:603–8.
43. **Fung C, Chang F, Lee S, et al.** A global emerging disease of *Klebsiella pneumoniae* liver abscess: is serotype K1 an important factor for complicated endophthalmitis? Gut 2002;50:420–4.
44. **Fang CT, Lai SY, Yi WC, et al.** *Klebsiella pneumoniae* genotype K1: an emerging pathogen that causes septic ocular or central nervous system complications from pyogenic liver abscess. Clin Infect Dis 2007;45: 284–93.
45. **Lin J, Chang F, Fung C, et al.** High prevalence of phagocytic-resistant capsular serotypes of *Klebsiella pneumoniae* in liver abscess. Microbes Infect 2004;6:1191–8.

46. **Chuang Y, Fang C, Lai S, et al.** Genetic determinants of capsular serotype K1 of *Klebsiella pneumoniae* causing primary pyogenic liver abscess. J Infect Dis 2006;193:645–54.
47. **Yu W, Ko W, Cheng K, et al.** Association between *rmpA* and *magA* genes and clinical syndromes caused by *Klebsiella pneumoniae* in Taiwan. Clin Infect Dis 2006;42:1351–8.
48. **Yeh KM, Kurup A, Siu LK, et al.** Capsular serotype K1 or K2, rather than *magA* and *rmpA,* is a major virulence determinant for *Klebsiella pneumonia* liver abscess in Singapore and Taiwan. J Clin Microbiol 2007; 45(2):466–71.
49. **Lee S, Chen Y, Tsai H, et al.** Predictors of septic metastatic infection and mortality among patients with *Klebsiella pneumoniae* liver abscess. Clin Infect Dis 2008;47:642–50.

From the Division of Infectious Diseases (TF), Upstate Medical University, Syracuse, New York; Division of Infectious Diseases, Department of Medicine, SUNY Upstate Medical University (CS, TE, WJ, MP), Syracuse, New York; the Division of Microbiology, Department of Microbiology and Immunology (DK), SUNY Upstate Medical University, Syracuse, New York.

Submitted June 18, 2015; accepted October 8, 2015.

The authors have no conflicts of interest to disclose.

Correspondence: Tasaduq Fazili, MD, Division of Infectious Diseases, Upstate Medical University, 725 Irving Avenue, Suite 311, Syracuse, NY 13210. (E-mail: fazilit@upstate.edu).