

CASE REPORT

Severe invasive disease caused by hypervirulent *Klebsiella pneumoniae*: a case report

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Abstract

Klebsiella pneumoniae (*K. pneumoniae*) is a common pathogenic bacteria that causes numerous infectious diseases. Hypervirulent *K. pneumoniae* (hvKP) can lead to invasive *K. pneumoniae* liver abscess syndrome, which can induce life-threatening multiple organ dysfunction syndrome or septic shock. We report a case of invasive *K. pneumoniae* liver abscess syndrome caused by hvKP and discuss the treatment options of this syndrome. Appropriate antimicrobial drugs should be administered to improve prognosis and prevent complications, and laboratory testing is essential to guide clinical management and optimize patient outcomes.

KeywordsHypervirulent *Klebsiella pneumoniae*; Antimicrobial therapy; Prognosis; Case report

1. Introduction

Klebsiella pneumoniae is a common Gram-negative pathogen known to cause various clinical infectious diseases, such as pneumonia, bacteremia, urinary infection, endophthalmitis, as well as liver abscess and meningitis. *K. pneumoniae* has been identified as the predominant cause of pyogenic liver abscess in Asia and also as a primary pathogen responsible for pyogenic liver abscess in China [1].

K. pneumoniae is divided into classic *K. pneumoniae* and hypervirulent *K. pneumoniae* (hvKP), according to differences in the characteristics of virulence. The hypervirulent phenotype of *K. pneumoniae* is associated with the development of a distinctive invasive syndrome [2]. Hypervirulent strains of *K. pneumoniae* often show hypermucoviscosity, a feature used to identify them as hvKP, and hvKP is the main pathogen responsible for liver abscess [3]. Liver abscess accompanied by multi-organ abscesses caused by hvKP is also called invasive *K. pneumoniae* liver abscess syndrome. This is a rare clinical condition characterized by a primary liver abscess in combination with abscesses of other distant organ, including the eyes, lungs and central nervous system [4, 5], and it most often occurs in patients with diabetes mellitus and hypertension [6]. The incidence of invasive *K. pneumoniae* liver abscess syndrome is high in Asia, and the prognosis is typically poor [7, 8]. Prompt diagnosis and active treatment can improve the outcome. Meropenem is a powerful broad spectrum carbapenem antibiotic, primarily used to treat severe infections, and it exhibits an extensive tissue distribution and decent blood-brain barrier penetration. We herein report a typical case of invasive *K. pneumoniae* liver abscess syndrome caused by hvKP and discuss the clinical characteristics of this case.

2. Case report

A 78-year-old Han Chinese woman was admitted to the intensive care unit (ICU) with symptoms of a 6-day history of fever, headache, loss of appetite and a 1-day history of unconsciousness. She had a 5-year history of type 2 diabetes mellitus and a 2-year history of hypertension. On admission, physical examination showed comatose state (Glasgow Coma Scale, GCS: 7) along with right eye swelling and vision loss (Fig. 1a). Laboratory tests revealed a white blood cell count of 25,110 cells/mm³ (reference range, 4,000-10,000 cells/mm³). Computed tomography (CT) of the eye showed inflammatory changes (Fig. 1b). Liver CT revealed liver abscesses in the right lobe (Fig. 2a,b), and lung CT demonstrated multiple lesions over the lung (Fig. 3). Contrast-enhanced magnetic resonance imaging identified a brain abscess (Fig. 4).

Based on the clinical data, the diagnosis of invasive liver abscess accompanied by pneumoniae, endogenous endophthalmitis and brain abscess was made. Blood samples were collected at admission for bacterial culture, and bacterial species identification and antimicrobial susceptibility testing were performed using a MicroScan Walkaway Plus System (Beckman Coulter, Brea, CA, USA). Empiric antibiotic treatment with intravenous high-dose meropenem (1.0 g Q8h) and blood glucose control with insulin were administered in the ICU, and on day 2 of hospitalization, the patient regained consciousness with a GCS of 13 and was able to follow commands. No drainage (percutaneous or surgical) of the liver abscess was performed, as the abscess was not liquefied and the systemic response to antibiotic therapy was favorable.

On day 4 of hospitalization, blood culture revealed *K. pneumoniae*. The result of the string test was positive as well, and diagnoses of hvKP bloodstream infection

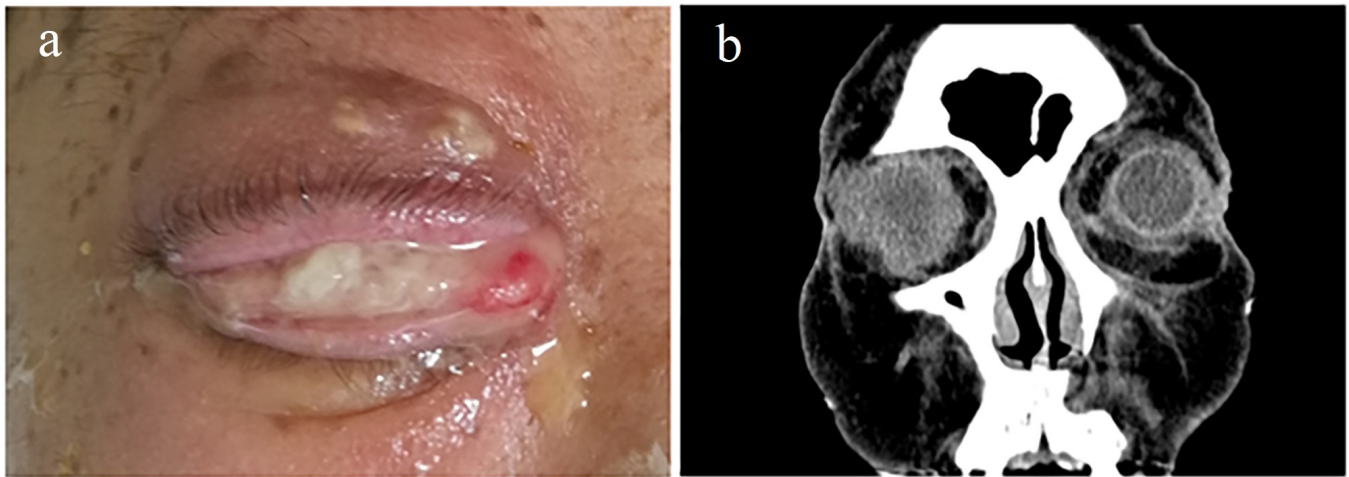


FIGURE 1. Visual appearance and computed tomography (CT) scan of the patient's right eye. (a). Right eye swelling with purulent discharge was visible. (b). The vitreous density of the right eye was uneven, and exudation was observed around the right eyeball.

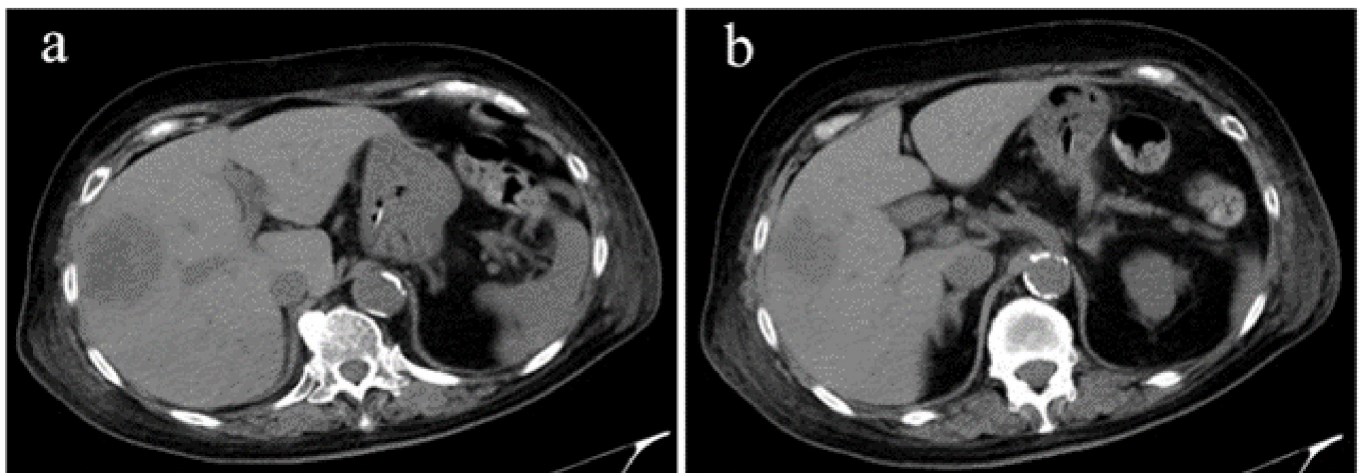


FIGURE 2. CT scans showing low-density areas in the right lobe of the liver. (a). The maximal diameter of the low-density areas in the right lobe was 4.65 cm. (b). A patchy low-density shadow was seen in the right lobe of the liver.

and invasive *K. pneumoniae* liver abscess syndrome were made. Antimicrobial susceptibility testing showed that the hvKP strain was sensitive to cefuroxime, piperacillin-tazobactam, ceftazidime, imipenem-cilastatin, meropenem, cefoperazone/sulbactam, and levofloxacin. Considering the ability of meropenem to penetrate the blood-brain barrier and the hyperactivity of the *K. pneumoniae*, the patient continually received intravenous infusions of meropenem over a 21-day course. Bedside ultrasound showed the size of liver abscesses decrease over time and the absence of liquefied abscesses. Thus, we did not conduct puncture and drainage operation. Because the primary site and systemic infection were controlled, de-escalation of the antibiotic was conducted, and levofloxacin was selected for better blood-brain barrier penetration and fewer side effects. The patient was then further treated with levofloxacin for 7 days. With the exception of those in the right eyeball, all other abnormalities on imaging disappeared after the patient was treated with a 30-day course of antibiotic therapy. The patient survived but

had right eye visual sequelae. At a 3-month follow-up after discharge from the hospital, the patient was doing well but had loss vision in the right eye.

3. Discussion

K. pneumoniae is a well-known Gram-negative pathogen causing nosocomial and community-acquired infections, and it is the primary pathogen responsible for liver abscess. Infection with hvKP typically presents as a community-acquired infection causing a liver abscess, and the most striking aspect of hvKP strains is their ability to induce severe infections not only in patients with low immunity but also in healthy individuals [9]. Invasive *K. pneumoniae* liver abscess syndrome caused by hvKP is a fatal infection that occurs rarely in western countries, but with a greater prevalence in Asian countries [10, 11]. Strains of hvKP confer a mucoid phenotype, and the string test is commonly used to determine the hypermucoviscous phenotype. The string test is considered positive when stretching of bacterial colonies on an agar plate with a

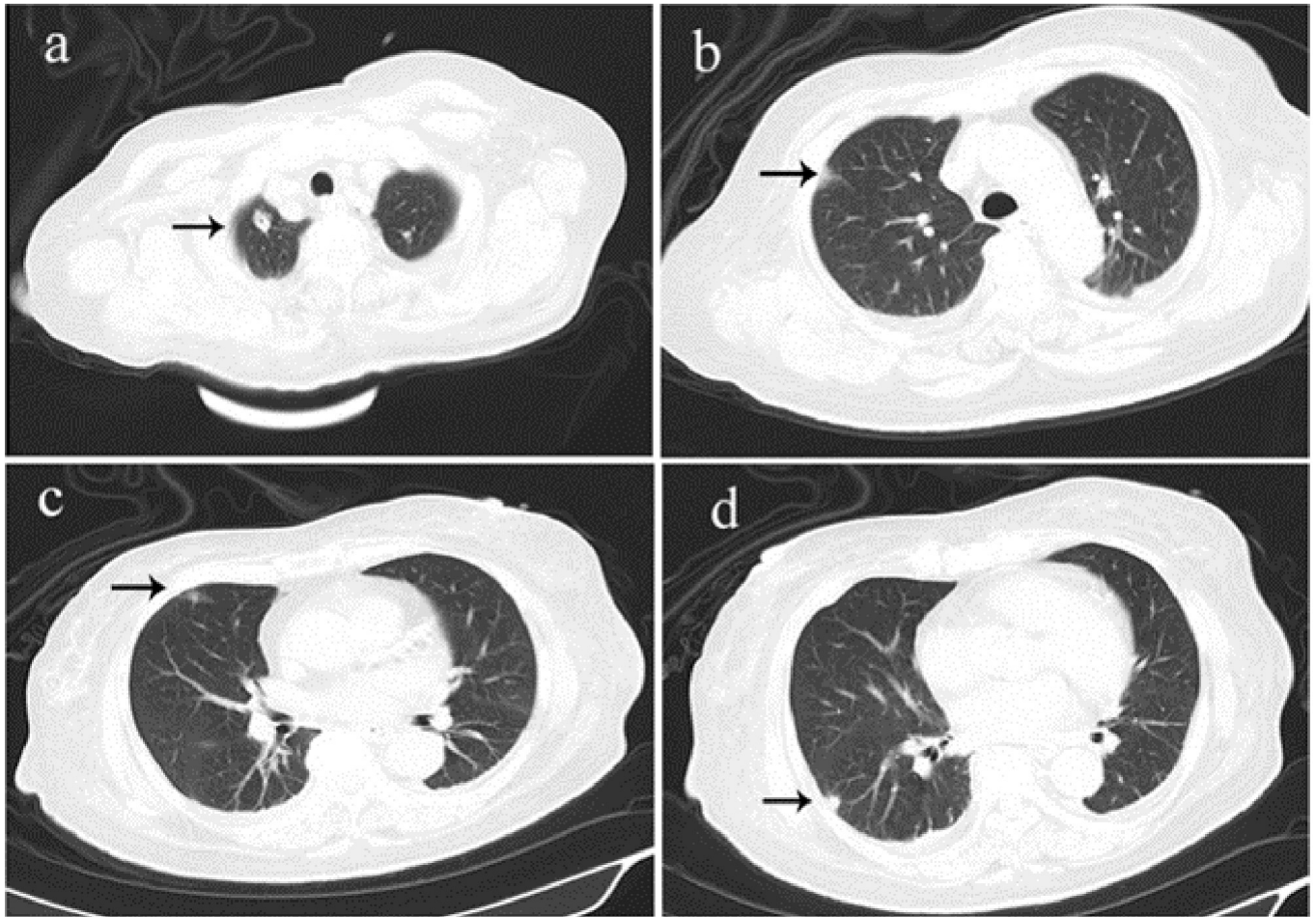


FIGURE 3. CT image of the patient’s lungs. (a). A small cavity was observed in the upper right lobe. (b) and (c). Ground-glass opacities were seen in the upper right lobe. (d). A solitary nodular shadow was visible in the lower right lobe near the pleura.

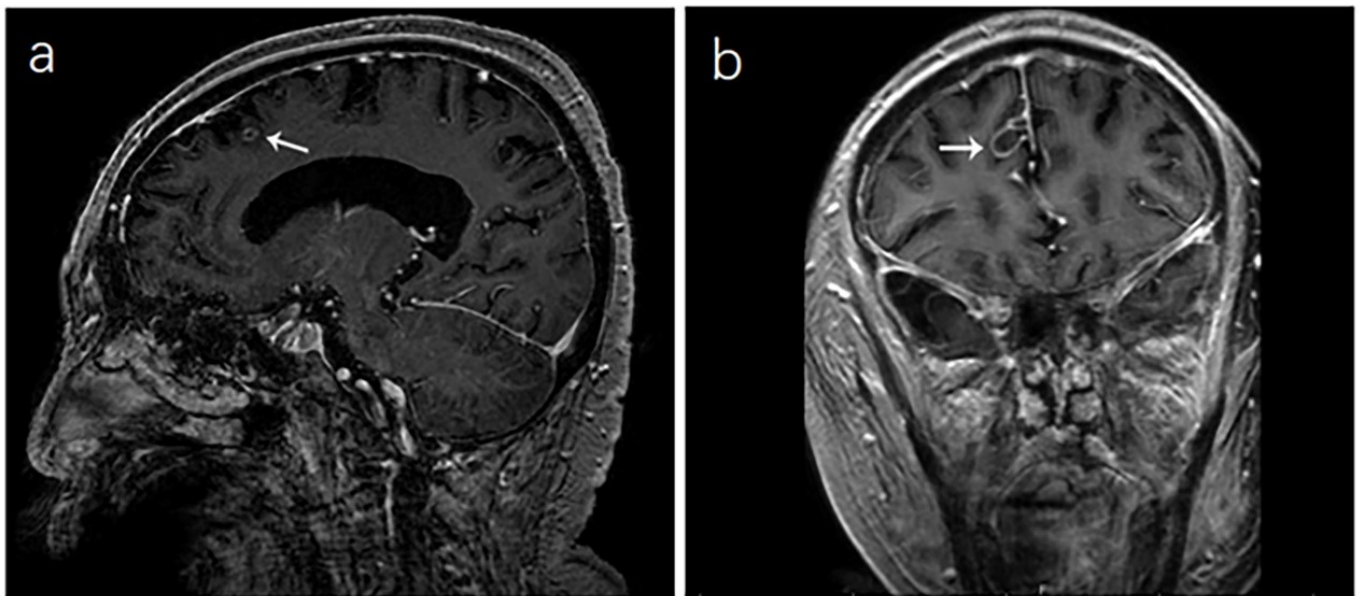


FIGURE 4. Contrast-enhanced magnetic resonance imaging of the brain. (a). Imaging on the sagittal plane revealed a ring-enhancing lesion (maximum diameter, 0.2 cm) located in the left forehead. (b). Imaging on the coronal plane showed a ring-enhancing lesion (maximum diameter 0.5 cm) in the left forehead.

bacteriologic inoculation loop can generate a viscous string > 5 mm in length [12]. Although confirmation of the hvKP was achieved by bacterial culture and string test in this case, bacterial culturing is time consuming. Next-generation sequencing (NGS) can also be used in the diagnosis of infectious diseases and offers the advantages of being more accurate and faster [13]. However, compared with the traditional approach, NGS is much more expensive.

The distinctive feature of community-acquired hvKP is its good susceptibility to most available antibiotics, such as third-generation cephalosporins, carbapenems, and fluoroquinolones [14, 15], but Hyun *et al.* reported that healthcare-associated hvKP showed differing antimicrobial susceptibility, with 20% resistance to cephalosporins [12]. The emergence of hypervirulent strains resistant to antimicrobial drugs will bring more challenges in clinical diagnosis and treatment. A rapid microbiological test to confirm the pathogen as early as possible is crucial for treatment. The case reported herein was characterized as community-acquired hvKP infection, and the hvKP was sensitive to most antibiotics, allowing the infection to be quickly controlled with the use of appropriate antibiotics. However, some patients require a long-course of anti-infective therapy, which evolves over months from inpatient treatment to outpatient intravenous antibiotic therapy.

Invasive *K. pneumoniae* liver abscess syndrome involves multiple organs. In addition to liver abscesses, hvKP can metastasize to distant sites, including the lungs, brain, eyes, kidneys, spleen, and bone marrow [16, 17]. The symptoms are nonspecific, such as fever, chills, nausea, vomiting, abdominal pain, dizziness, and vision loss. Of these, sight-threatening endophthalmitis has been commonly reported, and *K. pneumoniae* endogenous endophthalmitis typically has a poor visual outcome, with irreversible visual loss possible if appropriate and timely treatment is not applied [18–20]. Early diagnosis as well as prompt and proper treatment may preserve vision in some eyes.

There are some limitations to this case report. First of all, no specimens were sequenced, because NGS is quite expensive and difficult to implement in clinical routine, thus, we only relied on conventional microbial culture techniques and string test for the identification of hvKP. The etiological diagnosis should be well guided by the combination of microscopic examination, culture and NGS. Additionally, this was just a single case report, further cases are required to better understand the pathophysiology of invasive *K. pneumoniae* liver abscess syndrome. Finally, the patient in the present study was followed up for only 3 months, and these limitations need to be overcome in future studies.

In conclusion, invasive *K. pneumoniae* liver abscess syndrome caused by hvKP is a potentially fatal infection that can progress rapidly, early diagnosis and suitable treatment with antimicrobial agents and drainage of purulent material are vital to prevent severe and life-threatening complications. It is also essential to optimize the use of antibiotics in managing patients with these infections.

AUTHOR CONTRIBUTIONS

Qingdong Li and Yongli Zhang collected and analyzed the data. Yongli Zhang drafted the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The whole work was conducted in accordance with the Declaration of Helsinki. As this case report did not involve the application of experimental intervention during routine care, no formal research ethics approval was required.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this article.

CONSENT FOR PUBLICATION

Patient identifying information has been excluded from the manuscript, and written consent for publication of this case report and the accompanying images was obtained from the patient.

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