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Klebsiella pneumoniae Invasive Syndrome: The Fifth Case Reported in Portugal

Leonor Neves [1], Carolina Ribeiro Rodrigues [1], Rita Penaforte [1], Teresa Costa Pereira [1], Sofia Furtado [2]

1. Internal Medicine, Unidade Local de Saúde de Amadora/Sintra, Amadora, PRT 2. Internal Medicine Department of São Francisco Xavier Hospital, Unidade Local de Saúde de Lisboa Ocidental, Lisbon, PRT

Corresponding author: Leonor Neves, marialeonorneves.mi@gmail.com

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Abstract

We report the case of a 91-year-old Portuguese man recently hospitalized with *Klebsiella pneumoniae* community-acquired pneumonia complicated by a liver abscess, which showed complete radiological resolution following a 30-day course of targeted antibiotic therapy. Two months later, the patient presented with persistent chills, malaise, and elevated inflammatory parameters, prompting urgent abdominal imaging that revealed a left subphrenic abscess. Both blood and abscess fluid cultures yielded *K. pneumoniae* isolates with antimicrobial susceptibility profiles identical to those of the isolate recovered during the previous hospital admission, raising the possibility of a persistent or recurrent infection involving the same strain. K. pneumoniae invasive syndrome (KpIS) associated with a hypervirulent strain was suspected. Whole-genome sequencing of the isolate recovered during the second hospitalization identified genetic features associated with hypervirulence. To the best of our knowledge, this is the fifth case of KpIS reported in Portugal.

Categories: Epidemiology/Public Health, Internal Medicine, Infectious Disease
Keywords: europe, hypervirulent klebsiella pneumoniae (hvkp), klebsiella pneumoniae invasive syndrome (kpis), klebsiella pneumoniae (kp), liver abscess, portugal, subphrenic abscess, whole genome sequencing

Introduction

Klebsiella pneumoniae invasive syndrome (KpIS), although rare and variably defined in the literature, is increasingly recognized as a distinct clinical entity. First described by Liu et al. [1] as *K. pneumoniae* invasive liver abscess syndrome, it has been reported predominantly in Asian countries, particularly Taiwan, where the largest number of cases has been documented. In contrast, reports from non-Asian countries remain comparatively scarce and consist largely of isolated case reports [2].

Most presentations of *K. pneumoniae* infection are hospital-acquired and happen more frequently in patients with impaired host defenses, diabetes mellitus being the most common underlying condition (other risk factors include fatty liver disease, alcoholism, glucocorticoid and/or recent antibiotic therapy) [3,4]. Contrary to this, *K. pneumoniae* infections presenting as KpIS are mainly community-acquired and may occur in patients without any underlying risk factors. This is thought to be due to hypervirulent *K. pneumoniae* strains (hvKP), with a hyperviscous phenotype that makes them harder to eradicate despite not being naturally resistant to antibiotics, and also more prone to metastatic infection. [4] Extrahepatic septic metastases result from hematogenic dissemination and surge more frequently in the central nervous system (CNS), lungs, and musculoskeletal system, among others.

The presenting signs and symptoms of KpIS are similar to those of non-*K. pneumoniae* pyogenic liver abscesses: fever (93%), right upper quadrant tenderness (71%), leukocytosis (70%), elevation in liver enzymes (68%), elevation in alkaline phosphatase (78%), and elevation in bilirubin (26%) [5,6]. On imaging, *K. pneumoniae* liver abscesses tend to be solitary and of solid appearance. Specifically, on CT imaging, they are usually thin-walled, with little or no rim enhancement [7].

A diagnosis of KpIS is made when *K. pneumoniae* is isolated from blood cultures of a patient with imaging findings consistent with a liver abscess or, ideally, from the abscess aspirate itself. Once diagnosed, most patients respond to a four- to six-week course of directed antibiotic therapy. The drugs of choice are cephalosporins (with or without aminoglycosides) and extended-spectrum beta-lactams. Percutaneous CT-guided drainage may also be indicated in selected cases [8].

Although uncommon in non-Asian countries, prompt suspicion and confirmation of this entity is essential for an early diagnosis and prevention of metastatic complications. We report a case of a 91-year-old caucasian portuguese man with a recent history of *K. pneumoniae* community-acquired pneumonia complicated by right-sided empyema and liver abscess, who was readmitted two months later with suspected metastatic infection. After whole-genome sequencing (WGS) of the isolated *K. pneumoniae*, a diagnosis of metastatic KpIS associated with a hvKP was confirmed. To identify previously reported cases in Portugal, we conducted a targeted literature search in PubMed and Google Scholar, covering the period from

1986 (the year of the first description of the syndrome by Liu et al.) to [month/year of search], using the keywords "Klebsiella pneumoniae invasive syndrome", "Klebsiella pneumoniae liver abscess syndrome", "hypervirulent K. pneumoniae", and "Portugal". This search identified four previously published Portuguese cases, supporting our designation of the present case as the fifth reported in Portugal. Thus, to the best of our knowledge, this is the fifth case of KpIS reported in Portugal, following the reports of Neves et al., Pereira et al., Evangelista et al., and Matias et al. [9-12].

Case Presentation

A 91-year-old caucasian man was referred to the emergency department due to persistent high fever (40º C) and a week-long persistent state of malaise. His medical background was marked by a history of hypertension, dyslipidemia, moderate daily alcohol consumption, and a recent community-acquired pneumonia for which he had been started on empiric amoxicillin-clavulanate. His medical and family history was otherwise unremarkable; he had never smoked or consumed toxic substances, had no known allergies, and had no recent travel to foreign countries or contact with people in those circumstances.

On admission, his physical examination was normal apart from the fever, specifically without dyspnoea or abdominal pain. Laboratory findings showed over $28.0x10^9$/L leukocytes, a C-reactive protein level of 9.8 mg/dL, and liver enzyme elevation with a pattern of cholestatic lesion (Table *1*).

Variable	Reference range	1st hospital admission	1st hospital discharge	2nd hospital admission	2nd hospital discharge
Hemoglobin (g/dL)	12.0-15.0	9.8	11.2	9.1	11.0
MCV (fL)	83.0-101.0	105	97	100	99
Leukocyte count (×10^9/L)	4.0-10.0	28.0	6.4	11.6	6.0
Neutrophil count (% of leukocytes)	-	98	51	89	49
AST (U/L)	< 32	94	59	50	46
ALT (U/L)	< 33	77	30	28	24
ALP (U/L)	40-130	317	138	89	47
GGT (U/L)	< 40	430	161	107	65
Total bilirubin (mg/dL)	≤ 1.20	1.5	0.8	1.0	0.8
C-reactive protein (mg/dL)	< 0.50	9.8	1.4	10	1.1
Alpha-fetoprotein (ng/mL)	<7	<7	-	-	-
HBV and HCV serologies	-	Negative	-	-	-

TABLE 1: Laboratorial data showcasing the patient's evolution across the two hospitalizations

ALP - alkaline phosphatase; ALT - alanine aminotransferase; AST - aspartate aminotransferase; GGT - gamma-glutamyl transferase; HBV - hepatitis B virus; HCV - hepatitis C virus; MCV - mean corpuscular volume

Thoracic radiograph showed no visible consolidations. Antibiotic therapy was escalated to piperacillin-tazobactam on the assumption of microbiological resistance; however, the blood cultures drawn isolated a multisusceptible *K. pneumoniae* (Table *2*).

Variable	1st hospital admission	1st hospital discharge	2nd hospital admission	2nd hospital discharge
Blood cultures	Positive (x2) for multissusceptible *K. pneumoniae*	Negative	Positive (x3) for multissusceptible *K. pneumoniae*	-
Pleural fluid culture	-	-	Positive for multissusceptible *K. pneumoniae*	-
Subphrenic abscess aspirate culture	-	-	Positive for multissusceptible *K. pneumoniae*	-

TABLE 2: Microbiological data showcasing the patient's culture isolates across the two hospitalizations

This raised concerns of focus control, local complications, and/or distant infection spreading to tissues poorly penetrated by amoxicillin-clavulanate. To further investigate this hypothesis, a non-contrast thoraco-abdomino-pelvic CT scan was conducted, which documented a 15 mm thick layer of empyema-like fluid on the right, a 25 mm thick layer of pleural effusion on the left, and an ill-defined area of abnormal attenuation in hepatic segments V/VIII, measuring nearly 2.5 cm in maximum diameter, highly indicative of an immature abscessed lesion (Figure *1*).

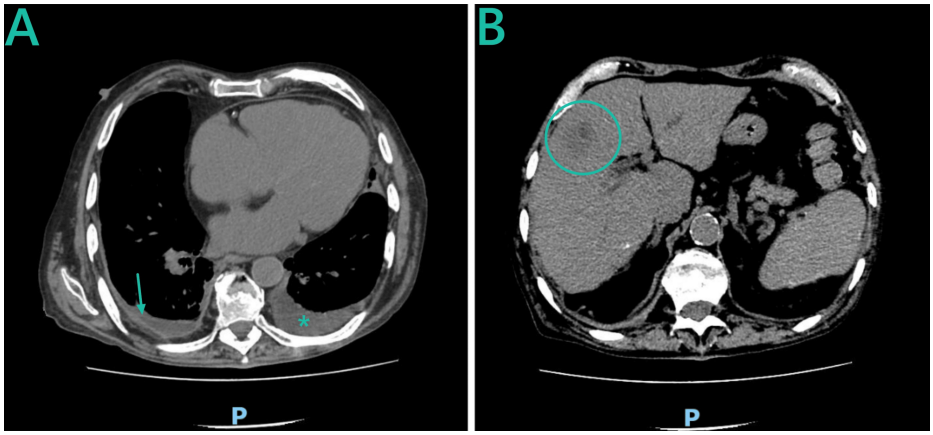


FIGURE 1: CT images acquired on the day of the first hospital admission

A: cross-sectional image of the thorax showing a moderate amount of empyema-like pleural fluid in the right hemithorax, 15 mm wide (arrow); and pleural effusion in the left hemithorax, 25 mm wide (asterisk).

B: cross-sectional image of the abdomen showing a 2.5 cm in maximum diameter, ill-defined area of abnormal attenuation in the hepatic segments V/VIII, highly indicative of an immature abscessed lesion (circle).

At that time, thoracocentesis was not performed since it was unsafe given the less than 3 cm interpleural distance of the suspected empyema. Hepatic biopsy was not performed either, due to the early stage of the abscess. Considering piperacillin-tazobactam's known efficacy in penetrating liver abscesses and the fact that there was a positive clinical response to it, no further changes in antibiotic treatment were made. Repeat blood cultures were negative after 10 days, and there was a continuous reduction in inflammatory markers (Table *2*). The patient underwent two control abdominal CT scans, respectively after 10 and 25 days under piperacillin-tazobactam, in which the liver abscess was reduced and resolved. The two CT scans also showed a marked reduction in empyema volume, down to a thin layer of residual fluid (Figure *2*). After a total of 30 days of piperacillin-tazobactam treatment, the patient was discharged.

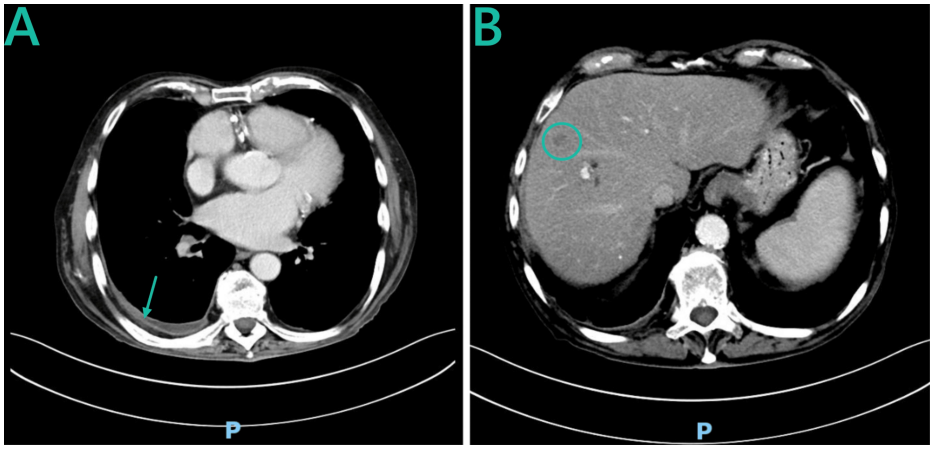


FIGURE 2: CT images acquired before the first hospital discharge, 25 days after antibiotic escalation to piperacillin-tazobactam

A: cross-sectional image of the thorax showing complete resolution of the left pleural effusion and marked volume reduction of the right empyema, 13 mm wide (arrow).

B: cross-sectional image of the abdomen showing a small attenuation in the hepatic segment V/VIII, consistent with a scar from an old hepatic abscess (circle).

Two months later, the patient presented at a follow-up consultation complaining of malaise and persistent chills, denying any other symptoms. Blood work showed re-elevation in inflammatory markers (Table *1*). An urgent thoraco-abdominal CT identified a bilateral pleural effusion and a left basal pneumonia in apparent transdiaphragmatic contiguity with a left subphrenic abscess, with a maximum diameter of 4 cm (Figure *3*), after which the patient was electively admitted to our ward and started on empiric piperacillin-tazobactam. Once again, blood cultures isolated multisusceptible *K. pneumoniae*, exhibiting an antimicrobial susceptibility profile identical to that of the isolate recovered during the first hospital admission. Although this finding raised the possibility of recurrence involving the same strain, confirmation was not possible due to the fact that whole-genome sequencing (WGS) was not done on the strain isolated during the first hospitalization. Given the patient's clinical stability and antimicrobial susceptibility test results, antibiotic therapy was de-escalated to ceftriaxone upon recommendation by the Department of Infectious Diseases.

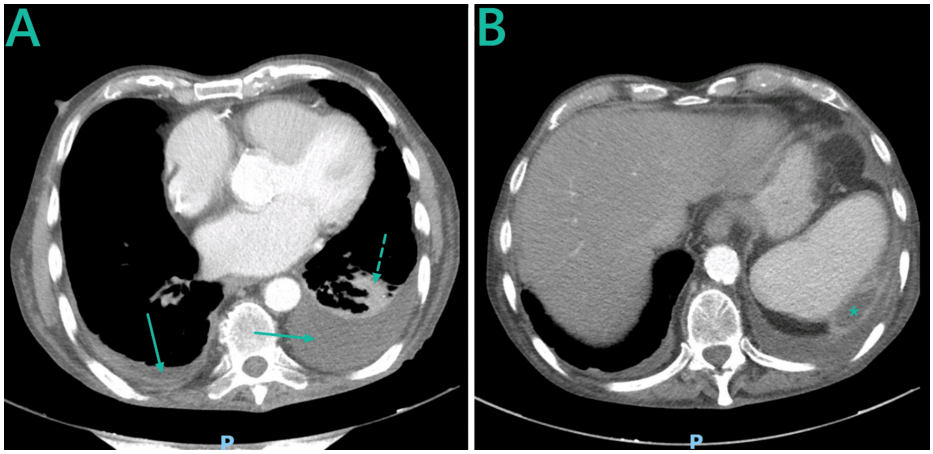


FIGURE 3: CT images acquired on the day of the second hospital admission

A: cross-sectional image of the thorax showing a bilateral pleural effusion (solid arrows) and a left base pneumonia (dashed arrow).

B: cross-sectional image of the abdomen showing a left subphrenic abscess, 4 cm in maximal diameter (asterisk), in apparent transdiaphragmatic contiguity with the aforementioned left base pneumonia.

At first, percutaneous drainage of the left subphrenic abscess was deemed not an option due to a high risk of

iatrogenic pneumothorax. However, control thoraco-abdominal imaging on day 14 of antibiotic therapy showed both growth of the abscess, now 6 cm in maximal diameter, and worsening of the left pleural effusion (Figure 4). At this point, oral metronidazole was added to the antibiotic therapy regimen for better empirical coverage of anaerobic bacteria. After multidisciplinary consultation with radiology and pneumology, both percutaneous drainage of the abscess and thoracocentesis were successfully conducted, respectively, with removal of 978 mL and 100 mL of serosanguinous exudate-like fluid. Both samples yielded *K. pneumoniae*.

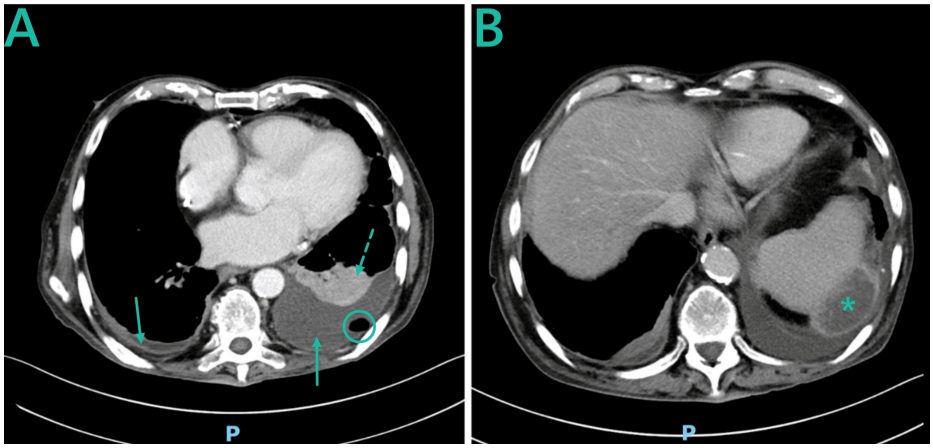


FIGURE 4: CT images acquired during the second hospital admission, on day 14 of ceftriaxone

A: cross-sectional image of the thorax showing worsening of both the left base pneumonia (dashed arrow) and the bilateral pleural effusion (solid arrows); the latter also showing some gas inclusions on the left side (circle).

B: cross-sectional image of the abdomen showing growth of the left subphrenic abscess, 6 cm in maximal diameter (asterisk).

Follow-up thoraco-abdominal CT on day 28 of antibiotic therapy showed recrudescence of both the subphrenic abscess and the empyema (Figure 5), leading to a new discussion with the Department of Infectious Diseases. Considering its previous success during the first hospital admission, antibiotic therapy was re-escalated to piperacillin-tazobactam.

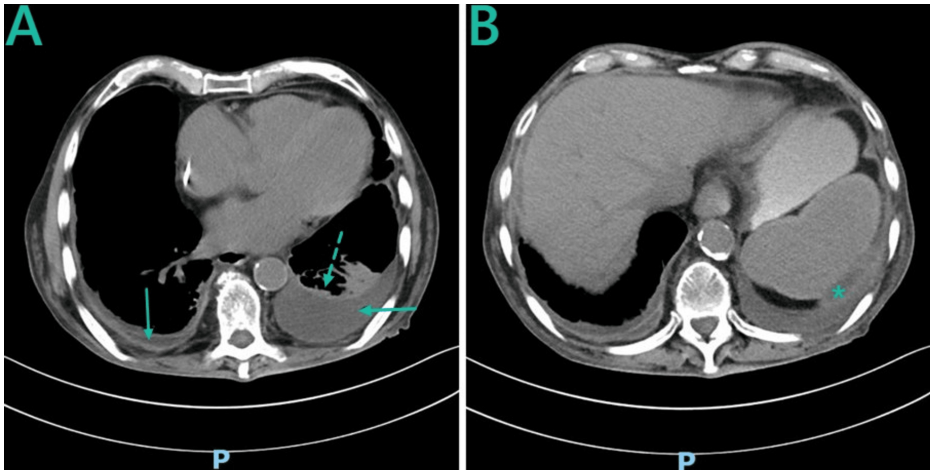


FIGURE 5: CT images acquired during the second hospital admission, 14 days post-drainage of both the empyema and the subphrenic abscess, on day 28 of ceftriaxone and day 14 of metronidazole

A: cross-sectional image of the thorax showing recrudescence of the empyema (solid arrows) despite radiological improvement of the left-base pneumonia (dashed arrow).

B: cross-sectional image of the abdomen showing recrudescence of the left subphrenic abscess (asterisk).

Repeat thoraco-abdominal imaging on day 14 of targeted piperacillin-tazobactam showed volume reduction of both the empyema and the abscess (Figure 6). Thus, in unanimous agreement with radiology, pulmonology, and infectious diseases, a decision was made not to attempt new percutaneous drainages. Screening for other foci of metastatic infection was negative, namely a PET-CT that showed no other areas of abnormal metabolic activity.

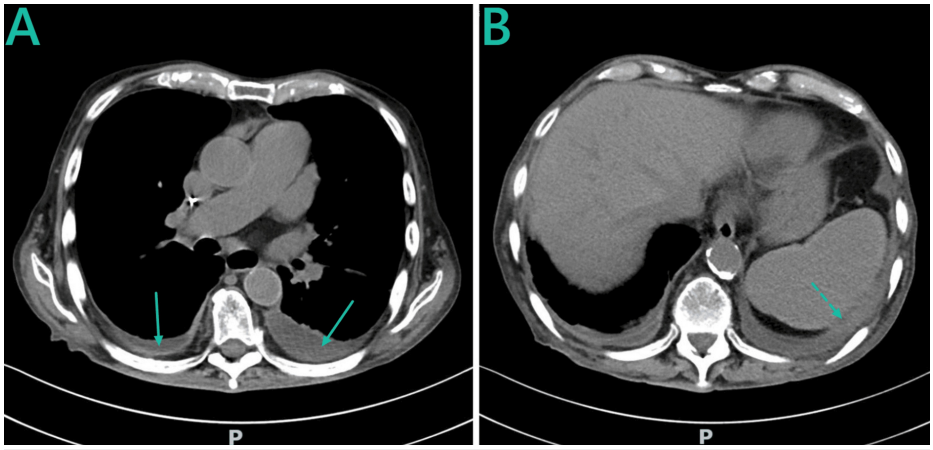


FIGURE 6: CT images acquired during the second hospital admission, 14 days after antibiotic escalation to piperacillin-tazobactam

A: cross-sectional image of the thorax showing resolution of left base pneumonia and marked volume reduction of the bilateral pleural effusion.

B: cross-sectional image of the abdomen showing volume reduction of the left subphrenic abscess (dashed arrow).

Following a review of the available literature, a diagnosis of KpIS was suspected and subsequently confirmed by WGS of the isolated *K. pneumoniae* strain at the Ricardo Jorge National Institute of Health. The strain was found to belong to serotype K1/K2 and to harbor several hypervirulence-associated genes, including regulator of mucoid phenotype A (rmpA), yersiniabactin locus, variant 2 (ybt2), salmochelin receptor gene (iroN), aerobactin biosynthesis locus, variant 3 (iuc3), and integrative and conjugative element of Klebsiella pneumoniae, type 1 (ICEKp1). Drawing on previously reported successful cases involving prolonged antibiotic therapy, we opted for an extended treatment course. Accordingly, on day 45 of hospitalization, the patient was discharged after completing 27 days of inpatient piperacillin-tazobactam, receiving a further 35 days of targeted piperacillin-tazobactam therapy through home-based outpatient parenteral antimicrobial therapy, for a total treatment duration of 62 days. One year later, the patient remains clinically well, with no further relapses or recurrence of infection.

Discussion

KpIS is an emerging clinical entity characterized by pyogenic liver abscess and a marked tendency for hematogenous dissemination leading to extrahepatic septic metastases [1]. It was first reported in Asia, particularly in Taiwan, while still remaining relatively rare in Western countries, where *K. pneumoniae* predominantly acts as an opportunistic healthcare-associated pathogen causing urinary, respiratory, or intravascular catheter infections [1,8,13]. On the other hand, primary bacteraemic liver abscesses occur almost exclusively as community-acquired infections [8,13].

In Europe, literature on KpIS is largely restricted to sporadic case reports [2,9-12]. To the best of our knowledge, the largest case series published in Europe dates back to 2011, detailing seven cases of invasive liver abscess from two different centers in France over two years, and in 2013, a report of three *K. pneumoniae* invasive liver abscess syndrome cases presenting to a single center in Ireland within one year. The remaining reported cases are scattered across countries such as Belgium, Italy, Spain, Sweden, and Portugal. Regarding Portugal specifically, published evidence remains scarce, with only four cases reported to date [9-12]. Our report adds to this limited literature by highlighting a complex presentation in a 91-year-old Caucasian male.

The pathophysiology and risk profile of KpIS differ substantially from classical *K. pneumoniae* infections such as bacteremia, pneumonia, and pyelonephritis [4,8,13]. The latter are mainly healthcare-associated and predominantly affect immunocompromised hosts, with diabetes mellitus, malignancy, and chronic pulmonary disease serving as major predisposing factors [2-4,8,13]. In contrast, KpIS is primarily community-acquired and can occur in patients without underlying predisposing comorbidities [8,13].

Nevertheless, diabetes mellitus remains the primary host risk factor (64.4% to 70.2% of KpIS cases), as poor glycaemic control impairs neutrophil phagocytosis of hypermucoid serotypes such as K1/K2 *K. pneumoniae* [3,5,6,13]. Although non-diabetic, our patient had a history of alcohol overconsumption and recent amoxicillin exposure - both recognized risk factors for community-acquired *Klebsiella* infections, which may have disrupted mucosal barriers to facilitate invasion [4,13].

Asymptomatic stool carriage of serotype K1/ST23 has been documented in healthy individuals and is strongly influenced by environmental exposure [13,14], providing a plausible mechanism for hvKP acquisition in a non-diabetic European patient without direct travel to endemic regions. Gastrointestinal translocation following asymptomatic intestinal colonization by *K. pneumoniae* is the most widely accepted hypothesis to explain systemic invasion and subsequent hepatic abscess formation [4,13]. However, alternative routes, such as transdiaphragmatic dissemination from pleural fluid, are also a possibility since he first presented during treatment for a presumed respiratory disease, complicated by a left empyema and abscess in hepatic segments VIII and V.

The heightened invasive potential of hvKP is primarily attributed to their resistance to innate immune clearance [4], driven by capsule serotypes (K1/K2) which prevent recognition by macrophage mannose receptors and surfactant protein A, hypermucoviscosity regulators (rmpA/rmpA2), and multiple iron-acquisition systems [3,4]. These promote hyperviscous phenotypes that resist host bactericidal mechanisms despite remaining susceptible to conventional antibiotics, while simultaneously driving a propensity for metastatic dissemination [3]. During the first admission, WGS was not performed because the *K. pneumoniae* strain isolated from our patient's blood cultures was multisusceptible and a straightforward clinical resolution was expected. However, due to the later recurrence, we decided to perform WGS on the second admission, which identified rmpA, ybt2, iroN, iuc3, and the integrative conjugative element ICEKp1. This provided essential diagnostic resolution because standard susceptibility antibiotic testing cannot distinguish classical from hypervirulent strains.

Secondary hematogenous dissemination and extrahepatic septic metastases occur in 11% to 14.6% of KpIS cases, most frequently involving the eyes, CNS, lungs, and musculoskeletal system [6,13]. In our patient, extensive imaging (including PET-CT) ruled out typical ocular or CNS lesions; instead, dissemination manifested as a left subphrenic abscess with contiguous pleural empyema. Furthermore, such solitary liver abscesses frequently present insidiously with fever (98.8%) and chills (69.0%), predominating over localized right upper quadrant pain (58.3%) [5]. This aligns with the absence of classic abdominal symptoms during both hospital admissions of our patient.

The clinical course illustrates the challenge of distinguishing successful initial treatment from complete eradication of an underlying invasive infection in KpIS. Despite negative blood cultures and 30 days of targeted antimicrobial therapy leading to complete radiological resolution of the hepatic lesion, the patient developed recurrent systemic inflammation two months later, with *K. pneumoniae* again isolated from blood cultures. Notably, the isolates recovered during both admissions exhibited identical antimicrobial susceptibility profiles. Although this raises the possibility that the second episode represented relapse or recrudescence involving the same strain, this could not be established in the absence of comparative genomic analysis. This highlights that in KpIS, apparent radiological resolution does not guarantee tissue sterilization and can mask persistent occult foci or delayed metastatic implantation.

Management of KpIS relies on two complementary principles: prolonged targeted antimicrobial therapy and adequate infection source control. Percutaneous catheter drainage slightly reduces overall mortality, but technical feasibility can be constrained by small size or proximity to critical structures [5,6]. In our case, drainage was initially delayed due to the risk of iatrogenic pneumothorax, and recurrence still occurred despite subsequent intervention, emphasizing the difficulty of source control in complex subphrenic/pleural collections, especially with a hvKP strain.

Hypervirulence and antimicrobial resistance represent distinct bacterial traits. HvKP strains frequently maintain full in vitro susceptibility to standard β-lactams [4,8], so treatment failure or relapse cannot simply be attributed to acquired resistance, but rather to inadequate drug penetration in the dense abscess matrix of hypermucoid strains, altered bacterial metabolic states, or incomplete source control. Re-escalation to piperacillin-tazobactam proved clinically effective in this patient, though such individual outcomes must be interpreted cautiously and do not establish clinical superiority over ceftriaxone or other standard first-line regimens. Given the lack of firm consensus regarding optimal antimicrobial duration in KpIS, management required a highly tailored regimen comprising a total of 62 days of intravenous antimicrobial therapy, achieving complete clinical and radiological resolution without recurrence at the one-year follow-up mark. Ultimately, while WGS is not routinely required for every *K. pneumoniae* isolate, its application in Western settings is invaluable when encountering atypical community-acquired invasive disease, recurrent infections, or metastatic dissemination.

The main limitation of this report is inherent to its single-case design, which precludes establishing causal relationships between individual virulence determinants and the clinical course or determining the optimal antimicrobial regimen and treatment duration for KpIS. Furthermore, although *K. pneumoniae* isolates

recovered during both hospital admissions exhibited identical antimicrobial susceptibility profiles, this finding alone cannot establish that they belonged to the same strain. In the absence of comparative genomic analysis, we cannot definitively distinguish between relapse or recrudescence caused by the original strain and a new infection caused by a genetically distinct hypervirulent *K. pneumoniae* strain with a similar susceptibility profile. Nevertheless, the matching susceptibility profiles and the temporal and clinical relationship between the two episodes raise the possibility of a persistent or recurrent infection involving the same strain, although this remains unproven.

Conclusions

In conclusion, hvKP-associated invasive disease must be considered in patients presenting with community-acquired *K. pneumoniae* bacteremia without a clear focus of infection or with a hepatic abscess, even in non-Asian individuals and in the absence of diabetes or other classic risk factors. Apparent radiological resolution of a primary focus does not guarantee complete tissue sterilization, nor does it exclude subsequent recrudescence or metastatic dissemination. Therefore, persistent or recurrent systemic inflammation should prompt immediate imaging and thorough microbiological re-evaluation. As such, management frequently requires individualized, extended antimicrobial regimens, including home-based outpatient parenteral antimicrobial therapy, and multidisciplinary reassessment, particularly when complete source control is technically challenging or delayed. Recognizing this invasive phenotype early is critical in non-endemic Western settings, where the diagnosis may otherwise be delayed or overlooked.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: Leonor Neves, Sofia Furtado

Acquisition, analysis, or interpretation of data: Leonor Neves, Rita Penaforte, Teresa Costa Pereira, Carolina Ribeiro Rodrigues

Drafting of the manuscript: Leonor Neves, Carolina Ribeiro Rodrigues

Critical review of the manuscript for important intellectual content: Leonor Neves, Rita Penaforte, Teresa Costa Pereira, Carolina Ribeiro Rodrigues, Sofia Furtado

Supervision: Leonor Neves, Sofia Furtado

Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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