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Case report

Contrast-enhanced ultrasound (CEUS) guided drainage in the treatment of a patient with lung abscess secondary to hypervirulent *Klebsiella pneumoniae* (hvKP) infection: A case report

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ABSTRACT

Hypervirulent *Klebsiella pneumoniae* (hvKP) can cause lung abscess, serious infection, and has a high mortality. Drainage plays a key role in the treatment of lung abscess secondary to hvKP. Contrast-enhanced ultrasound (CEUS) can identify necrotic areas within peripheral pulmonary lesions. We report a case in which thoracic CEUS using solution of sulfur hexafluoride microbubbles (SonoVue®, Bracco, Milan, Italy) was better than computed tomography (CT) in depicting lung abscess from consolidation secondary to hvKP, and its role in guiding drainage of lung abscess. CEUS is a promising imaging technique for confirming an appropriate time for drainage of lung abscess secondary to hvKP, for point-of-care application in critical patients with impaired renal function which may be aggravated by CT contrast medium.

1. Introduction

Over the past few decades, the hypervirulent *Klebsiella pneumoniae* (hvKP) infection has drawn scientists' eyes worldwide because of its increasing rate and its capacity to cause serious and metastatic infections in young and healthy individuals [1,2]. The prevalence of hvKP infection ranges from 8.33% to 73.9% in China [1]. Compared with classical *Klebsiella pneumoniae* (cKp), hvKP is more likely to cause lung abscess and has a higher mortality [3]. Treatment of lung abscess secondary to hvKP infection is important for prognosis. Drainage is important for the treatment of lung abscess. Contrast-enhanced ultrasound (CEUS) can identify necrotic areas within peripheral pulmonary lesions, which plays a useful role in imaging-guided biopsy [4]. We report a case in which thoracic CEUS depicted lung abscess from consolidation secondary to hvKP, providing an appropriate time and path for drainage, after computed tomography (CT) yielded inconclusive findings, and CEUS-guided drainage played a key role in the treatment of lung abscess.

2. Case presentation

A 57-year-old male with a long term of smoking history was admitted to our intensive care unit because of fever, cough, sputum for 2 days, and dyspnea for 1 day. Physical examination showed hypothermia (35.5 °C), tachypnea (29 bpm) with hypoxemia (SpO2 78%, intranasal oxygen inhalation, 8L/min), tachycardia (118 bpm), and blood pressure was 115/50 mmHg. Bilateral lung auscultation revealed moist rale. Arterial blood gas analysis showed hypoxygen (PaO2 68.8 mmHg), metabolic acidosis, and hyperlactatemia (7.09 mmol/L). Laboratory studies of the patient at admission were notable for infection and multiple organ injury (Table 1). Thoracic CT showed lung consolidation in the right upper lobe. Considering that the patient was suffering from septic shock, multiple organ dysfunction syndrome (MODS), we started to give fluid resuscitation, continuous renal replacement treatment, and organ protective therapy. After obtaining blood samples and sputum samples for culture, an empiric antibiotic therapy (piperacillin tazobactam and moxifloxacin) was started. Because of severe hypoxemia, the patient received nasal intubation, mechanical ventilation, and then prone position ventilation. On day 3, the cultures of blood and sputum samples resulted positive for *Klebsiella pneumoniae*, and antimicrobial susceptibility testing showed the strain was sensitive to piperacillin tazobactam. Further microbiology laboratory tests (the string test and wax moth larvae test) resulted positive for hvKP. After the treatments mentioned above, hypoxemia improved slightly, but was unstable because of the

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Table 1
Clinical laboratory results at the admission.

Measure	Reference range	Results
White cell count ($\times 10^9$/L)	4.00–10.00	4.31
Neutrophil pencent (%)	50.0–70.0	88.2
Platelet count ($\times 10^9$/L)	100–300	48
Hemoglobin (g/L)	110–160	150
C-reactive protein (g/L)	0.00–10.00	295.92
Procalcitonin (ng/ml)	0.00–0.05	>200.00
NT-proBNP (pg/mL)	40–100	>35000
Troponin T (pg/mL)	0.00–14.00	40.76
CK (U/L)	26.00–174.00	2639.00
CK-MB (U/L)	3.00–25.00	63.00
Blood urea nitrogen (mmol/L)	2.80–7.20	18.16
Creatinine (μmol/L)	45.00–104.00	513.00
Total bilirubin (μmol/L)	3.40–20.10	72.5
Alanine aminotransferase (U/L)	5.00–40.00	41.00
Aspartate Aminotransferase (U/L)	10.00–40.00	88.00
Cholinesterase (U/mL)	5.00–12.00	3.97

BNP = brain natriuretic peptide, NT-proBNP = N-terminal pro-BNP; CK = creatine kinase; CK-MB = MB isoenzyme of creatine kinase.

large amount of airway secretion, which needed repeated suction by bronchoscope. In addition, the hemodynamics of the patient was still unstable, and the dose of norepinephrine was about 0.5–0.8 μg/kg/min. Considering that pneumoniae was not well controlled, a second thoracic CT was performed on day 10, showing lung consolidation in the right upper lobe with the formation of an abscess, but no appropriate path for drainage (Fig. 1). On day 12, a CEUS was performed with a low mechanical index contrast-specific nonlinear technique (Cannon aplio 500). An intravenous bolus of 2.0 mL of an 8 μl/mL solution of sulfur hexafluoride microbubbles stabilized by a phospholipid shell (SonoVue®, Bracco, Milan, Italy) was used as the contrast agent. CEUS showed rapid and intense enhancement with hyperechoic pulmonary structure branching out from the center in the arterial phase, whereas the peripheral consolidation appeared as an anechoic lesion during the arterial phase and parenchymal phase (Fig. 2). The patient underwent CEUS-guided drainage of the anechoic lesion using a pigtail tube. Then, the patient's hypoxemia and hemodynamics improved gradually, and he was weaned from the ventilator on day 16. On day 21, the third thoracic CT showed that the lung lesion in the right upper lobe showed an improvement.

3. Discussion

HvKP was first reported in East Asia in the mid-1980s, as it caused serious disseminated infections in young and healthy individuals [1,5]. HvKP infections are characterized by community-acquired, multiple sites of infections, in young and healthy hosts. HvKP infections are increasingly being reported worldwide over the past few years, which has been a concern because the hvKP strains are life-threatening in young and healthy individuals [1,6]. When compared with cKP infection, hvKP infection has a higher mortality, which is up to 29.2% [3]. The 30-day mortality rate of hvKP-induced bloodstream infections was 37.1% [7]. Hiroki Namikawa et al. reported that the abscess was an independent predictor associated with hvKP bacteremia [3]. It is well known that the capsule is a virulence factor for cKP. HvKp is able to produce more capsular polysaccharides, which is mediated in part by RmpA and/or RmpA2, increasing the virulence and protecting itself against human defensin activities [8]. Like other members of the *Enterobacteriaceae* family, hvKP is capable of causing bacteremia, but the mechanism by which hvKp is more efficient in invading tissue from the bloodstream and inducing metastatic spread is unclear [8]. Moreover, the mechanism for hvKP causing abscesses in multiple sites is also incompletely clarified [8].

In our case, hvKP infection caused the formation of lung abscess and hvKP bacteremia in a non-immunocompromised adult, leading to septic shock, MODS. After the therapeutic strategies mentioned above in our case, the patient's hypoxemia and septic shock apparently did not improve, until the CEUS-guided drainage of the lung abscess was

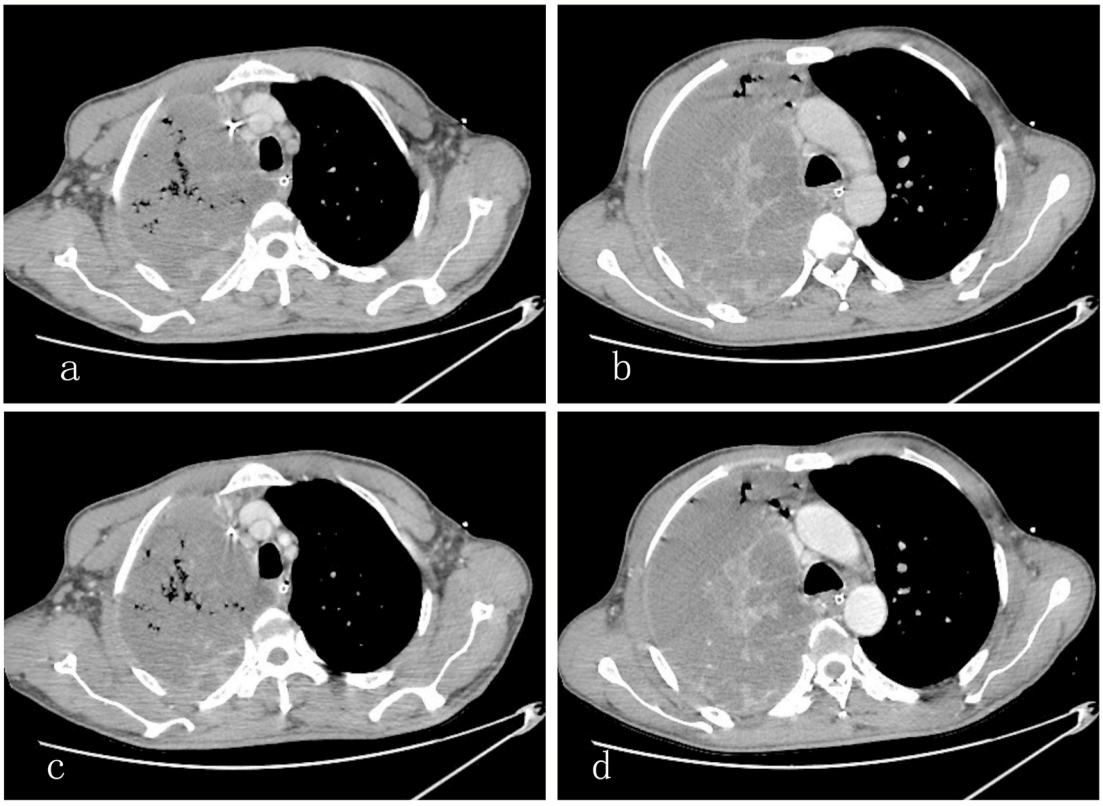

Fig. 1. Thoracic CT scan showed lung consolidation in the right upper lobe with formation of abscess, (c) and (d) were during the hyper-enhanced phase.

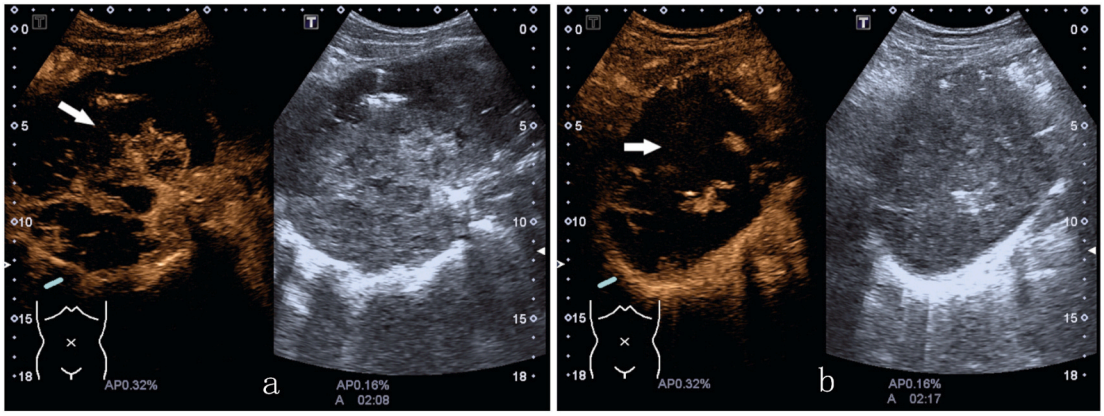

Fig. 2. Transverse scan of the right upper lobe in the contrast enhancement image and the gray scale image. The consolidation appeared as an anechoic lesion (white arrows in (a) and (b)).

performed. Therefore, the treatment of lung abscess secondary to hvKP infection is important for the outcome. With the development of modern medicine, the management of severe infection has greatly improved, but the mortality rate of hvKP infection is still quite high. Compared with cKP, hvKP is more likely to cause lung abscess, and treating the abscess could be a breakthrough to improve the prognosis of hvKP. Drainage plays a key role in the treatment of lung abscess, diagnosing the lung abscess earlier and providing an appropriate image-guiding drainage are very important for the treatment of lung abscess secondary to hvKP infection.

To date, CEUS has gained a well-established role in the detection and characterization of focal liver lesions. In addition, studies on its usefulness in pleuropulmonary pathology is increasing over the last few years. CEUS represents the best imaging method to evaluate the vascularity and transit time within an organ, providing a real-time observation [9]. The lung is characterized by dual blood supply, the bronchial arterial system and visceral pleura, providing the theory to differentiate non-neoplastic lesions from neoplastic lesions [9]. SonoVue® has an exclusively intravascular distribution that enables to distinguish perfused, viable tissues from necrotic tissues and helps to identify necrosis [10,11]. In our case, when the patient's pneumoniae was not well controlled, the second thoracic CT with contrast-enhanced showed the lung abscess, but could not provide an appropriate path for drainage. CEUS was better to depict the abscess from the consolidation of the lung, which might be because CEUS can provide real-time observation while the contrast-enhanced CT can only evaluate the vascularity of lung lesion at a certain point during the arterial phase [12].

Critical patients usually have difficulties to perform examinations outside the intensive care unit (ICU) because of unstable vital signs, such as CT examination. CEUS can be performed by the bedside, particularly for patients with unstable vital signs. Therefore, CEUS can be a promising point-of-care imaging technique performed in the ICU. Furthermore, for critical patients with impaired renal function, the use of a CT contrast medium may aggravate the renal injury, thereby limiting the differential diagnosis of lung abscess from the solidation of lung through CT without contrast-enhanced. As the microbubbles used do not influence the renal function, CEUS can be a choice to identify the lung abscess, particularly for those critical patients with impaired renal function [13].

In our case, CEUS played a key role in diagnosing the lung abscess that was then confirmed by CEUS-guided drainage, improving the patient's condition. Therefore, CEUS can identify necrotic areas within lung consolidation caused by hvKP, increase diagnostic accuracy, and help confirm the appropriate time to perform the drainage of lung abscess. Furthermore, CEUS can be performed by the bedside, thus making it a promising point-of-care imaging technique for critical patients, particularly for those with unstable vital signs and renal dysfunction.

4. Conclusions

In conclusion, hvKP is likely to cause lung abscess, serious infection, inducing a high mortality, confirming an appropriate time for the drainage of abscess is important for the treatment. CEUS using intravascular microbubbles can identify necrotic areas within lesions, and thereby plays a useful role in imaging-guided drainage. CEUS is also a promising imaging technique for point-of-care applications in critical patients, particularly in those with impaired renal function, which may be aggravated by CT contrast medium.

Funding source

None.

Declaration of competing interest

None.

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