Tropical Biomedicine 41(4): 461-463 (2024)
https://doi.org/10.47665/tb.41.4.006

CASE REPORT

Monitoring of ventilation in prone position in a patient diagnosed with scrub typhus and acute respiratory distress syndrome by using an electrical impedance tomography: a case report

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ARTICLE HISTORY

Received: 27 April 2024
Revised: 30 September 2024
Accepted: 30 September 2024
Published: 31 December 2024

ABSTRACT

Scrub typhus is an infectious disease caused by *Orientia tsutsugamushi*. It is transmitted through bite of chigger mite larvae and presents with symptoms such as fever, myalgia, headache, rash, and a characteristic eschar at the site of mite bites. This report details the case of a woman exhibiting acute febrile illness, bilateral pneumonia, and severe hypoxemia, prompting suspicion of scrub typhus due to the presence of a typical eschar on the pubic mound. The patient underwent combined therapy with azithromycin and doxycycline, alongside supplemental oxygen and prone positioning, with continuous monitoring facilitated by Electrical Impedance Tomography (EIT). Eventually the patient's symptoms improved. This case highlights the importance of timely identification of ARDS in scrub typhus patients and the utility of EIT in monitoring disease progression.

Keywords: Scrub typhus; acute respiratory distress syndrome (ARDS); Electrical Impedance Tomography (EIT); awake prone positioning.

BACKGROUND

Scrub typhus, caused by *Orientia tsutsugamushi* and transmitted through chigger mite larvae, is a life-threatening disease characterized by fever, myalgia, headache, rash, and a distinctive eschar resulting from mite bites (Li *et al.*, 2020). Eschar resulting from mite bites serves as a highly distinctive diagnostic clue (Kundavaram *et al.*, 2013). A severe complication of tsutsugamushi disease is Acute Respiratory Distress Syndrome (ARDS) (Wang *et al.*, 2007). Electrical Impedance Tomography (EIT) is a bedside-compatible, noninvasive imaging method that allows radiation-free monitoring of regional lung ventilation (Putensen *et al.*, 2019). We present a case study using electrical impedance tomography (EIT; Pulmovista 500, Drager) to assess the effect of a prone position on pulmonary ventilation in a patient with severe acute respiratory distress.

CASE HISTORY

A 71-year-old female patient was admitted to the emergency department with a complaint of recurrent fever for 5 days. She had been in a small wooded area before developing a fever. She sought treatment at her local health center, but her symptoms did not improve, prompting a referral to the Fourth Affiliated Hospital of Zhejiang University School of Medicine. The patient's past medical history, family history, and psycho-social history were unremarkable.

The patient had a BMI of 21, indicating an average weight. On presentation, the blood pressure was 95/56 mmHg, and the heart rate was 84 beats per minute. The body temperature was 36.6°C, and pulse oximetry was 99% on nasal cannula oxygen at 2 L/min. The physical examination showed a prominent pubic mound eschar was observed (Figure 1a), Table 1 provides the timeline for the study.

The results of the baseline laboratory examination showed that C-reactive protein (CRP) increased to 136.2 mg/L (Normal Range [NR]:< 6 mg/L). The serum concentration of Procalcitonin (PCT) increased to 1.522 ng/ml (NR: < 0.05 ng/ml). Blood cell analysis: leukocytes 5.9 × 10^9/L (NR: 3.5-9.5 × 10^9/L); neutrophil percentage

Table 1. Study timeline

Time	Procedure
Day 0	The patient was admitted to the ICU, and receieved Azithromycin (0.5g/day) combined with doxycycline (0.1g twice a day).
Day 3	The patient had poor oxygenation, the prone position was treated and ventilation was monitored with EIT.
Day 6	Patient oxygenation improved, we discontinued prone position therapy.
Day 15	Discontinue antibiotics and patient discharged.

94.3% (NR: 40.0–75.0%); lymphocytes 33.3% (NR: 20.0–50.0%); eosinophils 0% (NR: 0.4–6.0%); platelet 31 × 10^9/L (NR: 125-350 × 10^9/L). Alanine aminotransferase (ALT) increased to 160U/L (NR: 7-45 U/L). Extensive microbiological tests, including Weil-Felix, dengue serology, and blood culture, all results came back negative. The patient received empiric intravenous piperacillin-tazobactam therapy in the emergency department, administered at a dose of 4.5 g every 8 hours (Q8H), and vasoactive drugs were required, leading to admission to the intensive care unit.

Given the patient's history and skin manifestations, Scrub typhus was suspected. Blood metagenomic next-generation sequencing (mNGS) confirmed *Orientia tsutsugamushi.* Therefore, the patient was diagnosed with scrub typhus complicated by septic shock. Azithromycin (0.5g/day) combined with doxycycline (0.1g twice a day) was used to treat the patient. Although the patient's circulation improved rapidly and the inflammatory biomarkers decreased, the oxygenation index remained unstable. On the third day, the patient was diagnosed with Acute Respiratory Distress Syndrome (ARDS), as her oxygenation index was only 90% based on PaO2 / FiO2, and computed tomography (CT) chest images revealed extensive interstitial lung inflammation (Figure 1b). In response to severe ARDS, the patient was treated with nasal high-flow oxygen (FiO2 80% at a flow rate of 60 L/min) and prone position ventilation. Electrical Impedance Tomography (EIT) was used to monitor pulmonary ventilation before and after the patient underwent prone ventilation. The EIT results showed that before pronation (Figure 1c), the center of ventilation was distant from the target range. However, after three days of awake-prone positioning, oxygenation significantly improved, a chest CT scan review showed a significant improvement (Figure 1d), and the EIT results in the supine position (Figure 1e) showed that the center of ventilation was closer to the target range (around 50%), The patient's oxygenation improved, therefore we discontinued prone position therapy.

During prone position ventilation, patients felt easier to breathe, compliance was good, the patient's oxygenation index improved significantly, and inflammatory indicators continued to decline. Ultimately, the patient's condition improved enough to be discharged. No adverse or unanticipated events occurred during treatment.

DISCUSSION

Scrub typhus, one of the most common rickettsial infections, is endemic to the "tsutsugamushi triangle", which includes regions where 1 billion people live and are at risk of infection. An estimated 1 million cases of tsutsugamushi occur annually, accompanied by a notable high case fatality rate (Walker *et al*., 2013; Li *et al*., 2020; Devasagayam *et al*., 2021). Severe scrub typhus is characterized by the involvement of various organs, with pulmonary manifestations ranging from bronchitis to interstitial pneumonia, potentially progressing to acute respiratory distress syndrome (ARDS) (Jeong *et al*., 2007). The incidence of ARDS in scrub typhus is approximately 11%, and the mortality rate in cases where scrub typhus coexists with ARDS can increase to 25%(Wang *et al*., 2007). Advanced age, thrombocytopenia, and early pneumonitis have been identified as potential risk factors for the development of ARDS in patients with scrub typhus (Tsay & Chang, 1998).

In this case, EIT played a crucial role in facilitating prone positioning. Although computed tomography (CT) has been used to evaluate ventilation distribution, its clinical usefulness is limited due to the frequent radiation exposure, the risks associated with patient transport, and the lack of real-time dynamic information. In contrast, EIT provides dynamic tidal images of gas distribution at the patient's bedside, offering a radiation-free advantage (Frerichs *et al*., 2017; Bachmann *et al*., 2018).

In the present case, EIT played a pivotal role in managing ARDS secondary to scrub typhus, a rickettsial infection characterized by rapid disease progression and systemic complications. Scrub typhus-induced ARDS is particularly challenging to manage due to the acute and often unpredictable deterioration of lung function. While CT can identify structural abnormalities, it is unable to provide continuous ventilation data. EIT, on the other hand, bridges this gap by enabling real-time assessment of lung ventilation distribution, particularly during prone positioning. In this case, EIT allowed for the observation of improved oxygenation following prone positioning, a phenomenon that would not have been captured with CT alone.

The Center of Ventilation (CoV) serves as a metric for characterizing the spatial distribution of pulmonary ventilation. Initially defined as the weighted mean of the geometrical centers of ventilation in the dorsal-ventral direction for both lungs, CoV provides valuable insights (Putensen *et al*., 2019). Frerichs *et al*. established an experimental model of neonatal acute lung injury using the EIT method, observing a shift in the ventilation center induced by acute lung injury from the dependent to non-dependent area (Frerichs *et al*., 2006). In this case, the center of ventilation (CoV) increased from 45.2% to 47.5% after three days of prone positioning therapy. A CoV of 50% represents a balanced ventilation distribution along the dorsal-ventral axis of the thorax, indicating improved homogeneity. Recognizing the homogeneous ventilation distribution, we discontinued prone positioning ventilation treatment, highlighting the importance of EIT in guiding the respiratory management of patients. This case is the first documented use of Electrical Impedance Tomography (EIT) to monitor lung function in a patient with ARDS secondary to scrub typhus. While EIT has been utilized in ARDS management more broadly, its application in infectious ARDS, particularly scrub typhus, underscores its potential in managing rapidly evolving pulmonary dysfunction. The real-time data provided by EIT facilitated treatment adjustments and highlighted its potential for guiding personalized strategies in infectious ARDS cases. Future research should investigate EIT's broader application in managing infectious ARDS and optimizing ventilation strategies in critical care settings. A limitation of this study is that we were unable to perform an assessment of lung perfusion because the patient could not cooperate with breath holding maneuvers due to the severity of hypoxia. Consequently, we could not evaluate changes in lung perfusion using EIT before and after treating the patient in the prone position.

CONCLUSION

We report this case to emphasize the need for adequate attention to the possible complications in patients with scrub typhus, such as acute respiratory distress syndrome. Electrical impedance tomography (EIT) is a useful technique to assess ventilation distribution and lung homogeneity at the bedside. In this case, EIT was used to assess the lung status of this patient, which has great potential for clinical application and provides a valuable basis for decision-making.

Ethics statement

A written informed consent was obtained from the patient for publication of this article. Ethics approval and consent to participate: Passed the ethical review by the Ethics Committee of the Fourth Affiliated Hospital of Zhejiang University School of Medicine. Approval NO: K2023184.

Conflict of interest statement

The author declares that they have no conflict of interests.

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