

Culture-Confirmed Severe Methicillin-Susceptible *Staphylococcus aureus* Pneumonia with Lung Abscess, Bacteremia, and Hydropneumothorax Managed without ECMO: A Case Report

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Background: Methicillin-susceptible *Staphylococcus aureus* (MSSA) can cause rapidly destructive pneumonia complicated by lung abscess, bacteremia, empyema, and hydropneumothorax. Extracorporeal membrane oxygenation (ECMO) may be considered for refractory hypoxemia but is not always feasible. We report a young adult with severe MSSA pneumonia who recovered with optimized conventional support without ECMO.

Case Presentation: A 36-year-old man presented with fever, melena, hemoptysis, and progressive dyspnea. He developed severe hypoxemic respiratory failure with a PaO₂/FiO₂ ratio of 75 mmHg, septic shock requiring high-dose vasopressors, and extensive purulent airway secretions. ECMO was considered but declined for financial reasons. Immediate modified prone positioning was initiated through a rapid emergency-to-ICU workflow, and bronchoscopy performed in the prone position removed large volumes of purulent secretions. Computed tomography later showed right hydropneumothorax with approximately 60% lung compression and partial right lung destruction, as well as left pneumothorax with approximately 30% compression. Bilateral chest tubes were inserted with continuous negative-pressure drainage. Repeated early blood and sputum cultures grew *Staphylococcus aureus*, and oxacillin susceptibility with negative cefoxitin screening confirmed MSSA bacteremia and pneumonia. Antimicrobial therapy was dynamically adjusted according to microbiological results, including later isolation of carbapenem-resistant *Acinetobacter baumannii* and *Klebsiella pneumoniae*. Lesion-guided multi-segmental postural drainage was individualized according to imaging findings, air leakage, and drainage characteristics. The patient gradually improved, was weaned from mechanical ventilation, decannulated, and discharged on hospital day 80 with good functional recovery at follow-up.

Conclusion: Fulminant MSSA pneumonia with lung abscess, bacteremia, and bilateral hydropneumothorax may be managed without ECMO in selected patients when rapid, coordinated conventional support and source-control measures are feasible. Early prone positioning, timely pleural drainage, individualized postural drainage, dynamic antimicrobial adjustment, and stepwise rehabilitation may provide a feasible multimodal approach when advanced support is unavailable.

Keywords: Methicillin-susceptible *Staphylococcus aureus*, severe pneumonia, lung abscess, bacteremia, hydropneumothorax, prone positioning, postural drainage, case report

Background

Staphylococcus aureus is a common and potentially aggressive pathogen responsible for a wide range of infections, including pneumonia, bacteremia, and osteoarticular disease.^{1,2} Although methicillin-resistant strains (MRSA) often

receive greater attention, methicillin-susceptible *S. aureus* (MSSA) can also cause life-threatening pulmonary infection, particularly when associated with toxin-mediated injury, rapid tissue necrosis, and delayed infectious source control.³

Severe MSSA pneumonia may progress to necrotizing pneumonia, lung abscess, empyema, and hydropneumothorax, creating substantial management challenges. Extensive lung parenchymal destruction and pleural involvement may result in refractory hypoxemia. Abscess rupture or bronchopleural fistula can cause persistent air leakage and unstable respiratory mechanics. In addition, antimicrobial therapy alone may be insufficient when purulent collections, necrotic debris, or pleural space infection are not adequately controlled. Prolonged mechanical ventilation further increases the risk of ICU-acquired complications, including muscle weakness and difficult weaning.⁴

Initial antimicrobial treatment for severe community-acquired pneumonia is usually empirical and should cover the most likely pathogens according to illness severity, local epidemiology, and risk factors for drug-resistant organisms. Current guideline-based approaches recommend empirical MRSA coverage, most commonly with vancomycin or linezolid, when validated MRSA risk factors are present or when clinical features raise concern for resistant Gram-positive infection while awaiting microbiological confirmation.⁵ Once MSSA is confirmed and other pathogens have been excluded or appropriately covered, treatment should be narrowed to an antistaphylococcal beta-lactam, such as oxacillin, nafcillin, or cefazolin, whenever clinically appropriate.⁶ In complicated cases with empyema, hydropneumothorax, lung abscess, or bronchopleural fistula, antimicrobial therapy should be combined with timely drainage and other source-control measures.

For patients with severe acute respiratory distress syndrome (ARDS), prone positioning is a well-established intervention to improve oxygenation when feasible.⁷ Extracorporeal membrane oxygenation (ECMO) may be considered for refractory hypoxemia, yet it may not be available or may be declined because of resource limitations, cost, or patient/family preferences. In these circumstances, conventional management depends on early recognition, lung-protective ventilation, appropriate antimicrobial therapy, adequate pleural and airway drainage, and stepwise rehabilitation.

We present a 36-year-old man with community-onset MSSA pneumonia, clinically presumed to be community-acquired, that progressed within approximately one week from initial respiratory symptoms to lung abscess, bacteremia, bilateral hydropneumothorax, empyema, and partial lung destruction, resulting in acute hypoxemic respiratory failure. ECMO support was considered but ultimately not pursued. The patient recovered after early prone positioning, bilateral chest drainage, lesion-guided postural drainage, microbiology-guided antimicrobial therapy, and structured rehabilitation. This report is written in accordance with the CARE guidelines for case reports.⁸

Case Presentation

Patient Information

A 36-year-old man presented to the emergency department in late October 2024 with a several-day history of fever and upper respiratory tract symptoms. Two days before admission, he developed melena following alcohol consumption. One day before presentation, he experienced sudden hemoptysis and progressive dyspnea.

Initial evaluation suggested community-acquired pneumonia with respiratory failure and possible gastrointestinal bleeding. Chest computed tomography (CT) revealed multifocal bilateral pulmonary infiltrates, small bilateral pleural effusions, bronchiectasis in the upper lobes, mucus plugging in several bronchi, and localized emphysematous changes in the right upper lobe. On arrival, he remained conscious but was severely hypoxemic, with oxygen saturation of 81% despite oxygen delivered through a non-rebreather mask. He underwent emergency endotracheal intubation and was transferred to the intensive care unit (ICU) on invasive mechanical ventilation with a fraction of inspired oxygen (FiO₂) of 1.0.

Clinical Findings on ICU Admission

On admission to the ICU, the patient was febrile, with a temperature of 39.6 °C, tachycardia with a heart rate of 129 beats/min, and hypotension with a blood pressure of 89/38 mmHg. Respiratory rate was 18 breaths/min under mechanical ventilation. Arterial blood gas analysis revealed pH 7.30, PaCO₂ 48 mmHg, PaO₂ 75 mmHg, bicarbonate 23.6 mmol/L, base excess −2.9 mmol/L, and lactate 3.3 mmol/L, corresponding to a PaO₂/FiO₂ ratio of 75 mmHg and severe acute respiratory distress syndrome (ARDS). High-dose vasoactive support was required, including norepinephrine 0.73–0.80 µg/kg/min, epinephrine

0.18–0.20 µg/kg/min, and dobutamine 12.22–13.33 µg/kg/min, to maintain mean arterial pressure. Key physiological parameters, laboratory findings, imaging findings, microbiological results, and respiratory support at critical time points are provided in [Supplementary Table 1](#).

Given the profound hypoxemia and hemodynamic instability, veno-venous extracorporeal membrane oxygenation (ECMO) was considered. The family declined ECMO because of financial constraints. Management therefore centered on rapid optimization of oxygenation with prone positioning, airway clearance, microbiology-guided antimicrobial therapy, pleural drainage as needed, and early multidisciplinary rehabilitation. The main clinical events and overall management course are summarized in [Table 1](#).

Diagnostic Assessment

Severe methicillin-susceptible *Staphylococcus aureus* (MSSA) pneumonia complicated by bacteremia, lung abscess, right hydropneumothorax, and left pneumothorax was diagnosed on the basis of clinical features, imaging, and microbiological results. The infection was considered community-onset and clinically presumed to be community-acquired because fever and respiratory symptoms had developed several days before hospital presentation, chest CT at initial evaluation already showed multifocal bilateral pulmonary infiltrates, and early blood and sputum cultures obtained at admission or shortly thereafter grew *S. aureus*. Methicillin susceptibility was confirmed by automated antimicrobial susceptibility testing, with oxacillin susceptibility and negative cefoxitin screening. The complete antibiogram of the initial *S. aureus* isolate is provided in [Supplementary Table 2](#). Subsequent blood cultures remained positive during the early hospital course but turned negative from November 13 onward, documenting bacteremia clearance.

Table 1 Main Clinical Events and Management Timeline

Time Point	Clinical Event	Intervention	Outcome
Emergency department	Fever, melena, hemoptysis, and dyspnea; SpO ₂ 81% despite reservoir-mask oxygen	Emergency intubation; transfer to ICU on FiO ₂ 1.0	Invasive mechanical ventilation initiated
ICU admission	PaO ₂ /FiO ₂ 75 mmHg; lactate 3.3 mmol/L; shock requiring multiple vasoactive agents	ECMO was considered but declined; emergency-to-ICU rapid response workflow; modified prone-position ventilation; bronchoscopy in the prone position	Abundant purulent secretions removed; FiO ₂ reduced to 0.8 after prone positioning
Oct 31–Nov 10, 2024	Repeated blood and sputum cultures grew methicillin-susceptible <i>Staphylococcus aureus</i>	Antimicrobial therapy adjusted according to culture results, susceptibility testing, disease severity, and source-control status	Culture-confirmed MSSA pneumonia with bacteremia diagnosed
Nov 5, 2024	Recurrent oxygenation deterioration; CT showed right hydropneumothorax with approximately 60% lung compression and partial right lung destruction, and left pneumothorax with approximately 30% compression	Emergency bedside bilateral thoracic drainage using a three-chamber water-seal system with continuous negative-pressure suction	Persistent grade IV air leakage and purulent drainage observed
Nov 12, 2024	Persistent purulent pleural drainage	Ultrasound-guided percutaneous pleural catheterization at the right seventh intercostal space	Additional purulent pleural fluid drained
From Nov 13, 2024 onward	Repeat blood cultures became negative	Continued antimicrobial reassessment, respiratory care, pleural drainage, and airway clearance	Clearance of MSSA bacteremia documented
Dec 18, 2024	Fever resolved	Continued drainage, antimicrobial therapy, respiratory care, and rehabilitation	Body temperature returned to normal
Jan 19, 2025	Follow-up chest CT	Reassessment of pulmonary lesions and pleural cavity	Bilateral infiltrates and cavities markedly absorbed; right hydropneumothorax and empyema partially resolved
ICU day 26	Prolonged mechanical ventilation	Tracheostomy	Airway management optimized
Hospital day 52	Improved swallowing and respiratory condition	Oral intake resumed	Nasogastric feeding discontinued
Hospital day 57	Improved respiratory mechanics and oxygenation	Weaning protocol and rehabilitation support	Liberated from mechanical ventilation
Hospital day 74	Stable spontaneous breathing	Decannulation	Tracheostomy tube removed
Hospital day 80	Overall clinical improvement	Discharge planning and follow-up arranged	Discharged in improved condition

Abbreviations: CT, computed tomography; ECMO, extracorporeal membrane oxygenation; FiO₂, fraction of inspired oxygen; ICU, intensive care unit; MSSA, methicillin-susceptible *Staphylococcus aureus*; SpO₂, peripheral oxygen saturation.

Chest CT on November 5 showed right hydropneumothorax with approximately 60% compression of the right lung and partial destruction of the right upper and middle lobes, together with left pneumothorax causing approximately 30% lung compression. Persistent air leakage and purulent pleural drainage suggested rupture of a lung abscess into the pleural space. Follow-up CT on January 19, 2025, demonstrated substantial resolution of bilateral infiltrates and cavities, with partial improvement of the hydropneumothorax and empyema.

To rule out complications of *S. aureus* bacteremia, repeat blood cultures were monitored until clearance, and transthoracic echocardiography was performed. No. 1 evidence of infective endocarditis was identified. Inflammatory markers, including elevated white blood cell count, C-reactive protein, and procalcitonin, were consistent with severe infection, and no other infectious foci were found. The microbiological findings and antimicrobial treatment course, including antibiotic doses and dosing intervals, are summarized in [Table 2](#).

Therapeutic Interventions

Because ECMO was declined, management emphasized immediate optimization of conventional respiratory support, infectious source control, and stepwise recovery.

Initial Respiratory Support and Prone Positioning

Modified prone positioning was started immediately upon ICU arrival using a pre-prepared rapid-response workflow. The airway was secured, invasive monitoring lines were placed, and all tubes were aligned to minimize traction during turning. A team of four staff members, including nurses, a respiratory therapist, and a physician, performed the turn according to a standardized checklist, completing the procedure within 10 minutes. Sedation was maintained at a Richmond Agitation-Sedation Scale score of −4 to −5. Prone positioning improved oxygenation, allowing FiO₂ to be reduced from 1.0 to 0.8. Fiberoptic bronchoscopy performed in the prone position cleared large amounts of yellow purulent secretions from the airways.

Thoracic Drainage and Management of Hydropneumothorax

On November 5, when oxygenation deteriorated further, repeat CT confirmed bilateral pneumothorax/hydropneumothorax with significant lung compression. Emergency bedside insertion of bilateral chest tubes was performed, and the tubes were connected to a three-chamber water-seal system with continuous low negative-pressure suction. Persistent grade IV air leakage and purulent drainage were noted. On November 12, an additional ultrasound-guided pleural catheter was placed in the right seventh intercostal space to enhance drainage of purulent fluid. Drainage volume, air leakage, and fluid characteristics were monitored closely, with gentle tube milking applied when thick pus or necrotic material obstructed flow.

Antimicrobial Treatment

Following identification of MSSA in blood and sputum cultures, antimicrobial therapy was adjusted according to culture results, antimicrobial susceptibility testing, disease severity, organ function, and source-control status. At the time *S. aureus* was first detected, the patient was receiving piperacillin-tazobactam 4.5 g q12h plus linezolid 0.6 g q12h as empirical therapy for severe pneumonia and septic shock. Vancomycin was added after blood cultures grew *S. aureus*, with a 1.0 g loading dose followed by 0.5 g q12h, because full susceptibility results were not yet available and the patient had bacteremia with severe respiratory and hemodynamic instability.

After antimicrobial susceptibility testing confirmed MSSA, with oxacillin susceptibility and negative cefoxitin screening, linezolid was discontinued. Piperacillin-tazobactam and vancomycin were continued temporarily during the early unstable phase because of persistent bacteremia, extensive pulmonary destruction, pleural infection, and ongoing source-control procedures. Vancomycin was subsequently increased to 1.0 g q12h according to therapeutic drug monitoring. Because MSSA bacteremia persisted in early follow-up cultures, the regimen was later adjusted after multidisciplinary reassessment to include a short course of daptomycin 500 mg qd for the bloodstream infection component rather than as pneumonia-directed therapy. Cefazolin 1.0 g q6h was then introduced as MSSA-directed beta-

Table 2 Microbiological Findings, Isolated Organisms, and Antimicrobial Treatment Timeline

Date / Period	Sample / Test	Microbiological Findings	Clinical Interpretation	Antimicrobial Therapy and Doses	Clinical Notes
Oct 31–Nov 2, 2024	Blood culture; sputum culture	Blood and sputum cultures grew <i>Staphylococcus aureus</i> ; repeated sputum cultures remained positive for <i>S. aureus</i>	Early MSSA pneumonia with bacteremia; no other bacterial pathogen was documented at presentation	Piperacillin-tazobactam 4.5 g q12h started on Nov 1; linezolid 0.6 g q12h Nov 1–5; vancomycin started on Nov 2 with a 1.0 g loading dose followed by 0.5 g q12h	Empirical therapy was used for severe pneumonia and septic shock while awaiting full susceptibility results
Nov 4–5, 2024	Blood culture; sputum culture; antimicrobial susceptibility testing; chest CT	Blood and sputum cultures remained positive for <i>S. aureus</i> ; susceptibility testing showed oxacillin susceptibility and negative ceftiofur screening, confirming MSSA; CT showed right hydropneumothorax and left pneumothorax with marked lung compression	Persistent MSSA pneumonia and bacteremia with destructive pulmonary and pleural complications	Linezolid was discontinued after MSSA was identified; piperacillin-tazobactam 4.5 g q12h plus vancomycin 0.5 g q12h were continued	Bilateral chest tubes were inserted on Nov 5; purulent drainage and grade IV air leakage were observed
Nov 6–7, 2024	Blood culture; sputum culture; vancomycin therapeutic drug monitoring	Blood and sputum cultures remained positive for <i>S. aureus</i> ; vancomycin trough concentration was below target	Persistent MSSA positivity during the early unstable phase	Vancomycin was increased to 1.0 g q12h according to therapeutic drug monitoring; piperacillin-tazobactam 4.5 g q12h was continued	Antimicrobial therapy was adjusted because of persistent bacteremia and subtherapeutic vancomycin concentration
Nov 8–11, 2024	Sputum culture; blood culture	Sputum cultures repeatedly grew MSSA; blood culture on Nov 10 remained positive for MSSA	Persistent MSSA pneumonia and bacteremia	Vancomycin 1.0 g q12h continued; daptomycin 500 mg qd Nov 8–11	Daptomycin was used after multidisciplinary reassessment for the bloodstream infection component rather than as pneumonia-directed therapy
Nov 11–12, 2024	Blood culture; antimicrobial reassessment	Persistent MSSA infection during the early bacteremic phase	MSSA-directed beta-lactam therapy was attempted	Cefazolin 1.0 g q6h Nov 11–12; vancomycin 1.0 g q12h continued	Short-course cefazolin was used after reassessment of MSSA susceptibility and clinical status
Nov 12–18, 2024	Blood culture; sputum culture; pleural drainage	Blood cultures became negative on Nov 13 and Nov 16; sputum cultures began to show <i>Ralstonia mannitolilytica</i> ; purulent pleural effusion was drained	MSSA bacteremia cleared; <i>Ralstonia mannitolilytica</i> appeared later as a respiratory isolate during ICU treatment	Linezolid 0.6 g q12h Nov 12–22; meropenem 1.0 g q12h Nov 12–20; vancomycin continued until Nov 18, with dosing adjusted according to renal function and therapeutic drug monitoring	Additional right pleural catheter was inserted on Nov 12; clearance of MSSA bacteremia was documented
Nov 20–26, 2024	Blood culture; sputum culture; catheter-drawn blood culture	Repeated blood cultures remained negative; sputum cultures repeatedly showed <i>Ralstonia mannitolilytica</i> and occasional <i>Candida</i> species	No recurrent MSSA bacteremia; later ICU-associated respiratory isolates persisted	Cefoperazone-sulbactam 2.0 g q8h Nov 20–26; linezolid 0.6 g q12h continued until Nov 22; vancomycin was restarted on Nov 22, with dosing adjusted according to renal function and therapeutic drug monitoring	<i>Candida</i> species were intermittently detected but were not interpreted as bacterial pathogens

(Continued)

Table 2 (Continued).

Date / Period	Sample / Test	Microbiological Findings	Clinical Interpretation	Antimicrobial Therapy and Doses	Clinical Notes
Nov 26–Dec 5, 2024	Blood culture; sputum culture; pleural fluid culture	Repeated blood cultures remained negative; sputum cultures repeatedly showed <i>Ralstonia mannitolilytica</i> and occasional <i>Candida</i> species; pleural fluid culture on Dec 5 showed no growth	Later respiratory isolates during prolonged ICU treatment; no recurrent MSSA bacteremia	Piperacillin-tazobactam 4.5 g q8h restarted on Nov 26; vancomycin 0.5 g qd Nov 22–Dec 6; minocycline 100 mg bid p.o. added from Nov 29	Antimicrobial therapy was adjusted according to culture results, renal function, therapeutic drug monitoring, and clinical response
Dec 6–Dec 26, 2024	Sputum culture; pleural fluid culture; urine culture	Sputum cultures repeatedly showed carbapenem-resistant <i>Acinetobacter baumannii</i> (CRAB), sometimes with <i>Ralstonia mannitolilytica</i> or <i>Candida parapsilosis</i> ; pleural fluid cultures repeatedly showed CRAB from Dec 8 onward; urine cultures showed <i>Candida glabrata</i>	CRAB was detected as a later ICU-associated respiratory and pleural isolate	Piperacillin-tazobactam 4.5 g q8h continued; vancomycin 0.5 g qd and minocycline 100 mg bid p.o. were used during this period according to culture results, renal function, and clinical response	Late ICU course was complicated by repeated CRAB-positive respiratory and pleural cultures
Dec 28, 2024–Jan 13, 2025	Sputum culture; pleural fluid culture	Sputum cultures repeatedly showed CRAB with moderate growth of <i>Klebsiella pneumoniae</i> ; pleural fluid cultures continued to show CRAB; occasional <i>Candida parapsilosis</i> was detected in sputum	Persistent CRAB; later detection of <i>Klebsiella pneumoniae</i> in respiratory specimens	Piperacillin-tazobactam 4.5 g q8h continued; antimicrobial therapy was adjusted according to culture results, renal function, and clinical response	Persistent late respiratory and pleural microbiological complexity was observed; no recurrent MSSA bacteremia was documented

Notes: At presentation and during the early bacteremic phase, MSSA was the only documented bacterial pathogen and was considered the primary cause of the initial destructive pulmonary pathology, including lung abscess, bacteremia, hydropneumothorax, empyema, and partial lung destruction. Later detection of *Ralstonia mannitolilytica*, CRAB, and *Klebsiella pneumoniae* occurred during the prolonged ICU course and was interpreted in the context of mechanical ventilation, pleural drainage, repeated antimicrobial exposure, and clinical response. These later organisms may have contributed to the complexity and persistence of respiratory or pleural infection, but they were not considered the initiating cause of the early pulmonary destruction. *Candida* species are fungi rather than bacteria and were therefore not interpreted as bacterial pathogens. Vancomycin dosing was adjusted during the treatment course according to therapeutic drug monitoring, renal function, and clinical response.

Abbreviations: CRAB, carbapenem-resistant *Acinetobacter baumannii*; ICU, intensive care unit; MSSA, methicillin-susceptible *Staphylococcus aureus*; p.o., orally; qd, once daily; bid, twice daily; q6h, every 6 hours; q8h, every 8 hours; q12h, every 12 hours.

lactam therapy after reassessment of susceptibility and clinical status. Blood cultures turned negative from November 13 onward, confirming clearance of bacteremia.

No other bacterial pathogen was documented at presentation or during the early bacteremic phase. Therefore, the early infection was interpreted as culture-confirmed MSSA pneumonia with bacteremia. During the prolonged ICU course, additional organisms were later detected from respiratory or pleural specimens, including *Ralstonia mannitolitica*, carbapenem-resistant *Acinetobacter baumannii* (CRAB), and *Klebsiella pneumoniae*. These organisms were not isolated at the start and were interpreted as later ICU-associated respiratory or pleural isolates rather than evidence of mixed infection at presentation. *Candida* species were also intermittently detected, mainly from respiratory or urinary samples; these were described separately because they are fungi rather than bacteria and were not considered the primary bacterial pathogens of the initial pneumonia. Antimicrobial therapy was adjusted dynamically according to the timing of organism isolation, culture results, susceptibility information, renal function, therapeutic drug monitoring, and clinical response. The microbiological findings, including later bacterial isolates, corresponding antimicrobial agents, doses, and dosing intervals, are summarized in [Table 2](#).

Multi-Segmental Postural Drainage

Postural drainage was individualized according to disease stage, air leakage severity, imaging findings, and oxygenation tolerance rather than using fixed positions. In the early phase with prominent air leakage, the patient was kept mainly semi-recumbent or in right lateral decubitus with head-of-bed elevation of approximately 35° to facilitate air evacuation. After air leakage decreased, positions were adjusted to promote drainage of purulent material and necrotic debris.

For upper and middle lobe drainage, a high left lateral position with 45° head elevation and 40° body rotation to the left was performed every 2 hours during routine care. For lower lobe drainage, a 30° head-down tilt with 40° left rotation was limited to 5–10 minutes three times daily to avoid desaturation or reflux. For whole right lung drainage, a 20° head-up slope with left rotation and supportive pillow placement was maintained for about 1 hour twice daily as tolerated.

Before each session, gastric residual volume was checked, subglottic secretions were suctioned, cuff pressure was maintained at 35 cmH₂O, and enteral nutrition was temporarily reduced. Vital signs, tidal volume, and SpO₂ were monitored continuously; positioning was interrupted if oxygenation or ventilation worsened significantly. Large volumes of purulent and necrotic material were eventually evacuated through this combined approach.

Graded Rehabilitation

Rehabilitation was planned and adjusted daily by a multidisciplinary team, including a rehabilitation therapist, attending physician, and nurse, based on hemodynamic stability, oxygenation, muscle strength, and tube security. In the acute sedated phase, interventions included passive range-of-motion exercises, intermittent pneumatic compression, and airway clearance while maintaining prolonged prone positioning for more than 12 hours/day initially. As consciousness and stability improved, the patient progressed to active-assisted exercises, bedside sitting, cycling, resistance training, and eventual assisted walking, with gradual increases in distance from 50 m to 200 m. Activities were paused if blood pressure, heart rate, or oxygenation deviated beyond predefined safety limits.

Follow-up and Outcomes

The patient's fever resolved by December 18, 2024. He underwent tracheostomy on ICU day 26, resumed oral intake on hospital day 52, was weaned from mechanical ventilation on hospital day 57, and was decannulated on hospital day 74. He was discharged on hospital day 80 with improved general condition. Follow-up chest CT on January 19, 2025, confirmed marked improvement in pulmonary infiltrates, cavities, and pleural collections. At subsequent outpatient review, he reported no significant residual respiratory symptoms and maintained good functional recovery.

Patient Perspective

Following recovery, the patient described the prolonged mechanical ventilation, repeated drainage procedures, and rehabilitation as both physically exhausting and psychologically challenging. He noted that clear, repeated

explanations from the medical team and active family involvement helped him adhere to breathing exercises and progressive mobilization. He expressed satisfaction with the overall outcome and understood the importance of continued follow-up.

Discussion

This case illustrates that methicillin-susceptible *Staphylococcus aureus* can cause rapidly progressive and destructive pulmonary infection, even when the isolate is confirmed to be methicillin-susceptible.^{3,9} Recent literature also recognizes *S. aureus* as an important pathogen in necrotizing pneumonia, which may progress to cavitation, abscess formation, pleural complications, and severe respiratory failure.⁹ In the present patient, community-onset MSSA pneumonia, clinically presumed to be community-acquired, progressed within approximately one week from initial respiratory symptoms and within 4–5 days after hospital presentation to lung abscess, bacteremia, right hydropneumothorax, left pneumothorax, empyema, partial right lung destruction, severe hypoxemia, and hemodynamic instability. These complications created a complex clinical situation in which oxygenation, antimicrobial treatment, infectious source control, pleural drainage, airway clearance, and prevention of critical illness-related complications had to be addressed simultaneously.

The antimicrobial course needs to be interpreted in the context of the patient's initial severity and the evolving microbiological findings. At presentation, the patient had severe community-onset pneumonia, septic shock, acute hypoxemic respiratory failure, hemoptysis, gastrointestinal bleeding, and extensive bilateral pulmonary infection. Before culture and susceptibility results were available, severe bacterial pneumonia with possible additional pathogens and drug-resistant Gram-positive infection could not be excluded. Current pneumonia guidelines and recent reviews support empirical antimicrobial selection according to illness severity, local epidemiology, and risk factors for resistant organisms, with MRSA-active agents such as vancomycin or linezolid used when clinically indicated.^{5,6,9} Piperacillin-tazobactam was therefore started to provide broad empirical coverage for severe pneumonia, while linezolid was used for early Gram-positive coverage in the setting of severe destructive pneumonia. Vancomycin was added after early blood cultures grew *S. aureus* and before full susceptibility results were available, because the patient had bacteremia with worsening oxygenation and hemodynamic instability. This initial regimen reflected emergency empirical escalation in a critically ill patient and was not intended as a fixed standard combination.

Subsequent susceptibility testing confirmed MSSA, with oxacillin susceptibility and negative ceftioxin screening. Although antistaphylococcal beta-lactams, such as oxacillin, nafcillin, or cefazolin, are generally preferred for proven MSSA infection when clinically appropriate,^{6,10,11} the actual antimicrobial course required repeated adjustment because of persistent bacteremia, extensive lung destruction, pleural infection, organ dysfunction, and ongoing source-control procedures. After MSSA was identified, linezolid was discontinued, while piperacillin-tazobactam and vancomycin were continued temporarily during the early unstable phase. Vancomycin dosing was subsequently increased to 1.0 g q12h according to therapeutic drug monitoring. Because early follow-up cultures still showed MSSA bacteremia, a short course of daptomycin 500 mg qd was used after multidisciplinary reassessment for the bloodstream infection component rather than as pneumonia-directed therapy. This distinction is important because daptomycin is not considered appropriate for primary alveolar pneumonia owing to inhibition by pulmonary surfactant.¹² Cefazolin 1.0 g q6h was then introduced as MSSA-directed beta-lactam therapy after reassessment of susceptibility and clinical status. Blood cultures became negative from November 13 onward, and no recurrent MSSA bacteremia was documented in the available cultures.

The case was defined as MSSA pneumonia with bacteremia because this interpretation was supported by both the published literature and the patient's microbiological timeline. Previous reports and recent reviews have shown that *S. aureus*, including methicillin-susceptible strains, can cause necrotizing or destructive pneumonia with cavitation, lung abscess formation, pleural complications, and severe respiratory failure.^{3,9} In the present case, MSSA was repeatedly isolated from early blood and sputum cultures, and no other bacterial pathogen was documented at presentation or during the early bacteremic phase. Therefore, the initial destructive pulmonary process, including lung abscess formation, bacteremia, hydropneumothorax, empyema, and partial lung destruction, was most consistent with MSSA as the primary pathogen.

During the prolonged ICU course, additional organisms were later detected from respiratory or pleural specimens, including *Ralstonia mannitolilytica*, carbapenem-resistant *Acinetobacter baumannii* (CRAB), and *Klebsiella pneumoniae*. These organisms were not isolated at the start and were interpreted as later ICU-associated respiratory or pleural isolates rather than evidence of mixed infection at presentation. They may have contributed to later clinical complexity by increasing the respiratory or pleural infectious burden, prolonging airway or pleural inflammation, complicating antimicrobial selection, and potentially delaying radiological and ventilatory recovery. However, they were not considered the initiating cause of the early destructive pneumonia. *Candida* species were also intermittently detected, mainly from respiratory or urinary samples, but these organisms are fungi rather than bacteria and were not considered the primary bacterial pathogens of the initial pneumonia.

Antimicrobial therapy was modified over time according to culture results, susceptibility information, renal function, therapeutic drug monitoring, and clinical response. Later regimens included meropenem 1.0 g q12h, cefoperazone-sulbactam 2.0 g q8h, piperacillin-tazobactam 4.5 g q8h, minocycline 100 mg bid p.o., and vancomycin with dose adjustment when indicated. This course reflects the microbiological complexity of prolonged ICU treatment rather than failure of MSSA-directed therapy alone.

This case also emphasizes that antibiotics alone are unlikely to be sufficient in destructive staphylococcal lung infection with pleural involvement. The patient had extensive purulent airway secretions, lung abscess formation, bilateral hydropneumothorax, empyema, and persistent air leakage. These findings indicated a large burden of infected material and impaired natural drainage. Current literature and pleural disease guidance support timely drainage and source control in pleural infection.^{13,14} Repeated bronchoscopy, bilateral thoracic drainage, additional pleural catheter placement, continuous negative-pressure drainage, and individualized postural drainage were therefore central to source control. The clearance of bacteremia, absence of echocardiographic evidence of endocarditis, progressive radiological improvement, and eventual clinical recovery suggest that the favorable outcome resulted from the combination of microbiology-guided antimicrobial adjustment and aggressive source-control measures.

Several non-antimicrobial interventions may also have contributed to the favorable outcome despite the absence of extracorporeal membrane oxygenation. First, prone positioning was implemented immediately after ICU admission through a coordinated emergency-to-ICU workflow.^{7,15,16} At admission, the PaO₂/FiO₂ ratio was 75 mmHg under FiO₂ 1.0, and the patient required high-dose vasoactive support. Recent ARDS guidelines support early prone positioning in mechanically ventilated patients with moderate-to-severe ARDS and consideration of VV-ECMO in selected patients with severe ARDS.^{7,16} ECMO was considered because of the severity of hypoxemia but was not pursued because of financial constraints. Preparation of the airway, vascular lines, sedation, and team roles began before ICU arrival, allowing prone positioning within 10 minutes after admission. This rapid intervention, together with bronchoscopy performed in the prone position, facilitated removal of abundant purulent secretions and provided early support for oxygenation management.

The potential role of ECMO in this case should be interpreted cautiously. Given the initial PaO₂/FiO₂ ratio of 75 mmHg under FiO₂ 1.0, ECMO could reasonably have been considered as rescue support for severe hypoxemic respiratory failure.^{7,16,17} If veno-venous ECMO had been used, it might have provided temporary gas-exchange support, allowed lower ventilator intensity, reduced the risk of ventilator-induced lung injury, and created more time for antimicrobial therapy, bronchoscopy, pleural drainage, and other source-control measures to take effect. In the setting of bilateral pneumothorax/hydropneumothorax and persistent air leakage, ECMO-supported reduction of airway pressures might also have helped facilitate lung rest and limit further barotrauma. However, ECMO would not have directly treated the underlying MSSA pneumonia, lung abscess, empyema, bronchopleural fistula, necrotic lung tissue, or bacterial burden. These conditions would still have required effective antimicrobial therapy, repeated airway clearance, pleural drainage, and careful source control. In addition, ECMO usually requires systemic anticoagulation and specialized resources, which would have required careful risk assessment in this patient because of hemoptysis, gastrointestinal bleeding, pleural drainage, and repeated invasive procedures. Therefore, although ECMO might have improved early oxygenation and provided a bridge to infection control, it cannot be assumed that ECMO would have shortened the disease course or improved the final outcome in this single case. The present outcome should not be interpreted as

evidence that ECMO can be routinely avoided in comparable patients; rather, it suggests that selected patients may still recover without ECMO when conventional management is implemented rapidly and comprehensively.

Second, pleural and airway drainage were individualized according to evolving imaging findings and clinical needs.^{13,14} Initial bilateral chest tube insertion was performed to manage right hydropneumothorax, left pneumothorax, marked lung compression, and persistent air leakage, with priority given to continuous air evacuation to prevent further lung collapse. Once air leakage became more manageable, multi-segmental postural drainage was adjusted according to lesion distribution, drainage characteristics, and oxygenation tolerance. This staged approach, shifting from air evacuation to targeted removal of purulent and necrotic material, supported source control in a situation where fixed postural drainage would have been difficult because pneumothorax and lung destruction coexisted.

Finally, a structured rehabilitation program was started early while the patient was still receiving prolonged mechanical ventilation.^{4,18,19} Recent guidance on positioning and early mobilization in critically ill adults supports individualized mobilization strategies according to physiological stability, safety criteria, and interdisciplinary assessment.¹⁹ Rehabilitation began with passive range-of-motion exercises and airway clearance during deep sedation, then gradually advanced to active-assisted movements, resistance training, bedside sitting, standing, and supported walking as hemodynamic stability and muscle strength recovered. This stepwise approach appeared to limit ICU-acquired weakness and facilitated eventual weaning from ventilation, tracheostomy decannulation, return to oral intake, and functional recovery.

This report has several limitations. As a single case report, the favorable outcome cannot be attributed to any single intervention, and the findings may not apply to all patients with comparable disease severity. Although the timing of symptom onset, initial imaging findings, and early positive blood and sputum cultures supported community-onset infection, molecular typing, whole-genome sequencing, or epidemiological tracing was not performed. Therefore, the case is described as clinically presumed community-acquired MSSA pneumonia based on clinical timing and microbiological evidence, rather than definitive microbiological proof of strain origin. In addition, some detailed quantitative data, including serial PaO₂/FiO₂ ratios, daily drainage volumes, antimicrobial drug concentrations, inflammatory marker trends, and formal functional scores, were not fully documented. The antimicrobial course was complex and was influenced by evolving culture results, organ function, prolonged ICU treatment, and later ICU-associated pathogens. Long-term pulmonary function tests and extended imaging follow-up would have provided stronger outcome information. Since ECMO was declined for financial reasons, this case offers no direct comparison with ECMO-supported management. Therefore, any discussion of what might have occurred with ECMO remains hypothetical and should be interpreted cautiously. This case should be viewed as an illustration of coordinated multidisciplinary care under resource constraints, rather than evidence that ECMO can be routinely avoided in comparable situations.

Conclusions

In this patient, repeated early isolation of MSSA from blood and sputum cultures, together with the absence of other documented bacterial pathogens at presentation or during the early bacteremic phase, supported MSSA as the primary pathogen of the initial destructive pulmonary process. The later isolation of *Ralstonia mannitolilytica*, carbapenem-resistant *Acinetobacter baumannii*, and *Klebsiella pneumoniae* was interpreted as ICU-associated respiratory or pleural isolates that complicated the subsequent course rather than as evidence of mixed infection at presentation. This case indicates that culture-confirmed community-onset MSSA pneumonia may be associated with rapidly progressive lung abscess, bacteremia, hydropneumothorax, and life-threatening respiratory failure. When ECMO is unavailable or declined, early prone positioning, timely and individualized pleural/airway drainage, microbiologically guided antimicrobial therapy, and early graded rehabilitation may provide a feasible multimodal management pathway in carefully selected patients.

Abbreviations

ARDS, acute respiratory distress syndrome; CRAB, carbapenem-resistant *Acinetobacter baumannii*; CT, computed tomography; ECMO, extracorporeal membrane oxygenation; FiO₂, fraction of inspired oxygen; ICU, intensive care

unit; MIC, minimum inhibitory concentration; MRSA, methicillin-resistant *Staphylococcus aureus*; MSSA, methicillin-susceptible *Staphylococcus aureus*; PaCO₂, partial pressure of arterial carbon dioxide; PaO₂, partial pressure of arterial oxygen; PEEP, positive end-expiratory pressure; RASS, Richmond Agitation-Sedation Scale; SpO₂, peripheral oxygen saturation.

Data Sharing Statement

The datasets generated and/or analysed during the current case report are available from the corresponding author on reasonable request, subject to institutional policies and patient privacy protections.

Ethics Approval and Consent to Participate

This case report involved a retrospective analysis of anonymized clinical data. The study was reviewed and approved by the Ethics Committee of the First Affiliated Hospital, Zhejiang University School of Medicine (Approval No. [2025B] IIT Ethics Approval No. 0542, expedited review). The requirement for informed consent to participate was waived by the Ethics Committee because of the retrospective nature of the study and the use of anonymized clinical data.

Consent for Publication

Written informed consent for publication of this case report and any accompanying images was obtained from the patient.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare that they have no competing interests in this work.

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